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Special Project Specifications for Construction of Roads and Bridges

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DIVISION 550 – Bridge Construction

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DIVISION 550 - Bridge Construction

Section 551 - Driven Piles

Description

551.01 Work. Furnish and drive piles. In addition, furnish and place reinforcing steel and concrete in concrete-filled steel shell and concrete-filled pipe piles.

Piles are designated as steel H-piles, steel pipe piles, concrete-filled steel shell piles, concrete-filled pipe piles, precast concrete piles, prestressed concrete piles, or timber piles. Pile load tests are designated as static or dynamic.

Materials

551.02 Requirements. Furnish material that conforms to the specifications in the following sections and subsections:

Concrete Piles	715.03
Paint	708
Pile Shoes	715.08
Reinforcing Steel	554
Sheet Piles	715.07
Splices	715.09
Steel H-Piles	715.06
Steel Pipes	715.05
Steel Shells	715.04
Structural Concrete	552
Treated Timber Piles	715.02
Untreated Timber Piles	715.01

Construction

551.03 Pile-Driving Equipment. Furnish equipment meeting the following requirements:

(a) Pile Hammers. Furnish pile hammers as shown below.

(1) Gravity Hammers. Use gravity hammers to drive timber piles only, and where the ultimate bearing capacity of the timber pile is less than 90 tons. Furnish a hammer with a ram weighing between 2,000 and 3,500 pounds and limit the drop height to 15 feet. Ensure that the ram mass is greater than the combined mass of the drive head and pile. Provide hammer guides to ensure concentric impact on the drive head.

(2) Open-End Diesel Hammers. Equip open-end (single-acting) diesel hammers with a device, such as rings on the ram or a scale (jump stick) extending above the ram cylinder, to permit visual determination of hammer stroke. Submit a chart from the hammer manufacturer equating stroke and blows per minute for the hammer to be used. A speed-versus-stroke calibration may be used if approved.

(3) Closed-End Diesel Hammers. Submit a chart, calibrated to actual hammer performance within 90 days of use, equating bounce chamber pressure to either equivalent energy or stroke for the hammer to be used. Equip hammers with a dial gage for measuring pressure in the bounce chamber. Make the gage readable at ground level. Calibrate the dial gage to allow for losses in the gage hose. Verify the accuracy of the calibrated dial gage during driving operations by ensuring that cylinder lift occurs when bounce chamber pressure is consistent with the maximum energy given in the hammer specifications. Do not use closed-end diesel hammers that do not attain cylinder lift at the maximum energy-bounce chamber pressure relationship given in the hammer specification.

(4) Air or Steam Hammers. Furnish plant and equipment for steam and air hammers with sufficient capacity to maintain the volume and pressure specified by the hammer manufacturer. Equip the hammer with accurate pressure gages that are easily accessible. Use a hammer with the mass of the striking parts equal to or greater than one-third the combined mass of the driving head and pile. Ensure that the combined mass is at least 2,750 pounds.

When driving test piles, measure inlet pressures for double acting and differential acting air or stream hammers with a needle gage at the head of the hammer. If required, also measure inlet pressures during the driving of the production piles. A pressure-versus-speed calibration may be developed for the specific driving conditions at the project as an alternative to periodic measurements with a needle gage.

(5) Nonimpact Hammers. Do not use nonimpact hammers, such as vibratory hammers, unless permitted in writing, SHOWN ON THE DRAWINGS, or provided in the SPECIAL PROJECT SPECIFICATIONS. If permitted, use such equipment for installing production piles only after the pile tip elevation, or embedment length, for safe support of the pile load is established by static or dynamic load testing. Control the installation of production piles when using vibratory hammers by power consumption, rate of penetration, specified tip elevation, or other acceptable methods that will ensure the required pile load capacity is obtained. On one out of every ten piles driven, strike with an impact hammer of suitable energy to verify that the required pile capacity is obtained.

(b) Approval of Pile-Driving Equipment. Furnish pile-driving equipment of such size that the production piles can be driven with reasonable effort to the required lengths without damage.

The Government will evaluate the suitability of the equipment and will accept or reject the driving system within 21 days of receipt of the pile and driving equipment information. Approval of pile-driving equipment will be based on a wave equation analysis under the following conditions:

- When dynamic load testing is required.
- When ultimate pile capacities exceed 270 tons.
- When precast or prestressed concrete piles are used.
- When double-acting or differential hammers, air, steam, or diesel are used.

When the wave equation analysis is not used, approval of the pile-driving equipment will be based on minimum hammer energy in Table 551-1. Approval of a pile hammer relative to driving stress damage does not relieve the Contractor of responsibility for damaged piles.

Table 551-1 - Minimum Pile Hammer Energy

Ultimate Pile Capacity (tons)	**Minimum Rated Hammer Energy (Ft-lbs)**
≤ 90	10,300
150	15,600
180	20,700
210	26,500
240	33,100
270	40,100
>270	Wave equation required

If the wave equation analysis shows an inability to drive the pile(s) to the required ultimate pile-bearing capacity with an acceptable blow count, or that pile damage will occur, change the proposed driving equipment until the wave equation analysis indicates that piles can be driven as specified. Submit proposed changes to the CO for review.

Approval of the pile-driving system is specific to the equipment submitted. If the proposed equipment is modified or replaced, resubmit the revised data for approval before using. The revised driving system will be accepted or rejected within 21 days of receipt of the revised pile, equipment, and wave equation analysis information (if required). Use only the approved equipment during pile-driving operations.

(1) Equipment Submittal. Submit two copies of the following pile-driving equipment information at least 30 days before driving piles. When dynamic load tests are required, submit a wave equation analysis performed by a pile specialty consultant who meets the requirements specified in Subsection 551.12(a). If dynamic load testing is not required, the Government will perform the wave equation analysis.

(a) General. Project and structure identification, pile driving contractor or subcontractor, and auxiliary methods of installation, such as jetting or preboring, and the type and use of the equipment.

(b) Hammer. Manufacturer, model, type, serial number, rated energy (_____ at _____ length of stroke), and modifications.

(c) Capblock (Hammer Cushion). Material, thickness, area, modulus of elasticity (*E*), and coefficient of restitution (*e*).

(d) Pile Cap. Helmet mass, bonnet mass, anvil block mass, and drivehead weight.

(e) Pile Cushion. Cushion material, thickness, area, modulus of elasticity (*E*), and coefficient of restitution (*e*).

(f) Pile. Pile type, length (in leads), mass per foot, wall thickness, taper, cross-sectional area, design pile capacity, description of splice, and tip treatment description.

(2) Wave Equation. The required number of hammer blows indicated by the wave equation at the ultimate pile capacity shall be between 3 and 15 per inch. In addition, ensure that the pile stresses resulting from the wave equation analysis do not exceed the values at which pile damage is impending. The point of impending damage is defined for steel, concrete, and timber piles as follows:

(a) Steel Piles. Limit the compressive driving stress to 90 percent of the yield stress of the pile material.

(b) Concrete Piles. Limit the tensile (*TS*) and compressive (*CS*) driving stresses to:

$TS \leq 3\ f_c^{'} + EPV$

$CS \leq 0.85\ f_c^{'} - EPV$

where

$f_c^{'}$ = 28-day design compressive strength of concrete

EPV = effective prestress value (prestressed piles only)

(c) Timber Piles. Limit the compressive driving stress to 3 times the allowable static design stress.

(3) Minimum Hammer Energy. Ensure that the energy of the driving equipment submitted for approval, as rated by the manufacturer, is at least the energy specified in Table 551-1 that corresponds to the required ultimate pile capacity.

(c) Driving Appurtenances. Furnish the driving appurtenances shown below.

(1) Hammer Cushion. Equip all impact pile-driving equipment, except gravity hammers, with a suitable thickness of hammer cushion material to prevent damage to the hammer or pile and to ensure uniform driving behavior. Fabricate hammer cushions from durable, manufactured material in accordance with the hammer manufacturer's recommendations. Do not use wood, wire rope, or asbestos hammer cushions. Place a striker plate, as recommended by the hammer manufacturer, on the hammer cushion to ensure uniform compression of the cushion material. Inspect the hammer cushion in the presence of the CO when beginning pile-driving at each bent or substructure unit or after each 100 hours

of pile-driving, whichever is less. Replace the cushion when its thickness is reduced by more than 50 percent of its original thickness or when it begins to burn.

(2) Pile Drive Head. Provide adequate drive heads for impact hammers, and provide appropriate drive heads, mandrels, or other devices for special piles, in accordance with the manufacturer's recommendations. Align the drive head axially with the hammer and pile. Fit the drive head around the pile head so that it will prevent transfer of torsional forces during driving while maintaining proper alignment of hammer and pile.

(3) Leads. Support piles in line and position with leads while driving. Construct pile driver leads to allow freedom of movement of the hammer while maintaining axial alignment of the hammer and the pile. Do not use swinging leads unless permitted in writing, SHOWN ON THE DRAWINGS, or provided in the SPECIAL PROJECT SPECIFICATIONS. When swinging leads are permitted, fit swinging leads with a pile gate at the bottom of the leads and, in the case of battered piles, with a horizontal brace between the crane and the leads. Adequately embed the leads in the ground or constrain the pile in a structural frame (template) to maintain proper alignment. Provide leads of sufficient length that do not require a follower and will permit proper alignment of battered piles.

(4) Followers. Followers are not permitted unless approved in writing. When followers are permitted, drive the first pile in each bent or substructure unit and every tenth pile driven thereafter, full length without a follower, to verify that adequate pile embedment is being attained to develop the required ultimate pile capacity. Provide a follower of such material and dimensions that will permit the piles to be driven to the required penetration. Hold and maintain the follower and pile in proper alignment during driving.

(5) Jetting. Do not use jetting unless approved in writing. Provide jetting equipment with sufficient capacity to deliver a consistent pressure equivalent to at least 100 pounds per square inch at two 3/4-inch jet nozzles. Jet so as not to affect the lateral stability of the final in-place pile. Remove jet pipes when the pile tip is at least 5 feet above the prescribed tip elevation, and drive the pile to the required ultimate pile capacity with an impact hammer. Control, treat, if necessary, and dispose of all jet water in an approved manner.

551.04 Pile Lengths. Unless otherwise specified, furnish piles with sufficient length to obtain the required penetration and bearing capacity and extend into the pile cap or footing as SHOWN ON THE DRAWINGS. In addition, increase the length to provide fresh heading and to provide for the Contractor's method of operation. When test piles are required, furnish piles in the lengths determined by the test piles, increased to provide for the Contractor's method of operation.

551.05 Test Piles. Construct test piles at locations SHOWN ON THE DRAWINGS. Excavate the ground at the site of each test pile or production pile to the elevation of the bottom of the footing or pile cap before the pile is driven. Furnish test piles that are longer than the estimated length of production piles. Drive test piles with the same equipment as the production piles.

Drive test piles to the required ultimate capacity at the estimated tip elevation. Allow test piles that do not attain the required ultimate capacity at the estimated tip elevation to "set up" for 24 hours before redriving. Warm the hammer before redriving begins by applying at least 20 blows to another pile. If the required ultimate capacity is not attained on redriving, drive a portion or all of the remaining test pile length and repeat the "set up" and redrive procedure as directed. Splice and continue driving until the required ultimate pile capacity is obtained.

Ensure that test piles that are used in the completed structure conform to the requirements for production piles. Remove test piles that are not incorporated into the completed structure to at least 2 feet below finished grade.

Do not order piling to be used in the completed structure until test pile data have been reviewed and the production pile order lengths are determined. The CO will provide an estimated length list or pile order list within 10 days after completion of all test pile driving.

551.06 Driven-Pile Capacity. Drive piles with approved pile-driving equipment to the specified penetration and to the depth necessary to obtain the required ultimate pile capacity. Splice piles that do not obtain the required ultimate capacity at the ordered length and drive with an impact hammer until the required ultimate pile capacity is achieved.

Use the dynamic formula to determine ultimate pile capacity of the in-place pile, unless the wave equation is required in accordance with Subsection 551.03(b).

(a) Wave Equation. Adequate penetration will be considered to be obtained when the specified wave equation resistance criteria are achieved within 5 feet of the designated tip elevation as SHOWN ON DRAWINGS. Drive any piles that do not achieve the specified resistance within these limits to a penetration determined by the CO.

(b) Dynamic Formula. Drive the piles to the penetration necessary to obtain the ultimate pile capacity in accordance with the following formula:

$$RU = 1.6\sqrt{eE}\ \log_{10}(10N) - 100$$

where:

RU	=	Ultimate pile capacity in kips
E	=	Manufacturer's rated hammer energy in foot/pounds at the ram stroke observed or measured in the field
$\log_{10}(10N)$	=	logarithm to the base 10 of the quantity 10 multiplied by N
e	=	Hammer efficiency factor

Use: 0.72 for all diesels
0.67 for conventional single acting ECH (external combustion hammers), including rope driven hammers
0.50 for conventional double acting ECH
0.95 for free fall rams or hammers with internally measured impact velocities

N = Number of hammer blows per inch at final penetration

(1) Jetted Piles. Determine the in-place ultimate capacity of jetted piles based on impact hammer blow counts (dynamic formula) after the jet pipes have been removed. After the pile penetration length necessary to produce the required ultimate pile capacity has been determined by impact hammer blow count, install the remaining piles in each group or in each substructure unit to similar depths with similar methods. Confirm that the required ultimate pile capacity has been achieved by using the dynamic formula.

(2) Vibratory Hammers. The ultimate bearing capacity of piles driven with vibratory hammers will be based on impact driving blow count after the vibratory equipment has been removed. When vibratory installation of the piles is approved by the CO and the vibrated piles do not attain the required ultimate pile-bearing capacity at the specified length, splice them as required without compensation, and drive with a specified impact pile hammer until the required ultimate pilebearing capacity is achieved.

(3) Conditions for Dynamic Formula. The dynamic formula is applicable only if all of the following criteria apply:

(a) The hammer is in good condition and operating in a satisfactory manner.

(b) The hammer ram falls freely.

(c) A follower is not used.

(d) The head of the pile is not broomed or crushed.

(c) "Set Period" & Redriving. If piles do not attain the required bearing capacity when driven to the specified length, allow the piles to stand for a "set period" without driving. The "set period" shall be a minimum of 24 hours unless otherwise approved by the CO. After the "set period," perform check driving on either 2 piles in each bent or on 1 pile in 10 piles, whichever is more. The CO will designate the piles on which check driving is to be performed. Do not use a cold hammer for redriving. Warm up the hammer before redriving begins by applying at least 20 blows to another pile. Perform redriving by driving the pile to the required bearing with a maximum of 15 blows. If the specified hammer blow count is not attained on redriving, the CO may require driving all of the remaining pile length and repeating the "set period" and redriving procedure. Splice any piles driven to plan grade that do not attain the hammer blow count required, and drive until the required bearing is obtained. If the required bearing capacity is attained for each pile that is redriven, then the remaining piles in that bent will be considered satisfactory when driven to at least the same penetration and resistance as the redriven piles.

551.07 Preboring. Unless otherwise provided in the SPECIAL PROJECT SPECIFICATIONS, prebore holes to natural ground when piles are driven through compacted embankments more than 5 feet in depth. Use augering, wet rotary drilling, or other approved methods of preboring. Except for piles end bearing on rock or hardpan, stop preboring at least 5 feet above the pile tip elevation and drive the pile with an impact hammer to a penetration that achieves the required ultimate pile capacity. Preboring may extend to the surface of the rock or hardpan where piles are to be end bearing on rock or hardpan. Seat installed piles into the end bearing strata.

Prebore holes smaller than the diameter or diagonal of the pile cross section while allowing penetration of the pile to the specified depth. If subsurface obstructions such as boulders or rock layers are encountered, the hole diameter may be increased to the least dimension adequate for pile installation. After driving is completed, fill any void space remaining around the pile with sand or other approved material. Do not use a punch or a spud in lieu of preboring.

Do not impair the carrying capacity of existing piles or the safety of adjacent structures. If preboring disturbs the load carrying capacities of previously installed piles or structures, restore the required ultimate capacity of piles and structures by approved methods.

551.08 Jetting. Jetting will be permitted only when SHOWN ON THE DRAWINGS or approved in writing by the CO. When jetting is not required, but approved at the Contractor's request, determine the number of jets and the volume and pressure of water at the jet nozzles necessary to freely erode the material adjacent to the pile without affecting the lateral stability of the final in-place pile. Control, treat if necessary, and dispose of all jet water in a satisfactory manner. Drive all jetted piles with an approved impact hammer.

551.09 Preparation & Driving. Perform the work specified in Section 206 prior to driving piles. Make the heads of all piles plane and perpendicular to the longitudinal axis of the pile. Coordinate pile driving so as not to damage other parts of the completed work.

Drive piles to within 2 inches of plan location at cutoff elevation for bent caps, and within 6 inches of plan location for piles capped below finished ground. Ensure that the pile is no closer than 4 inches to any cap face and no closer than 9 inches to the face of any footing. Drive piles so that the axial alignment is within ¼ inch/foot of the required alignment. The CO may stop driving to check the pile alignment. Check the alignment of piles that cannot be internally inspected after installation before the last 5 feet are driven. Do not pull laterally on piles or splice to correct misalignment. Do not splice a properly aligned section on a misaligned pile.

Unless otherwise SHOWN ON THE DRAWINGS, drive piles at least 15 feet below the footing or cap. If the required minimum penetration cannot be obtained, provide a larger hammer, prebore or jet holes, or use other methods approved by the CO and in accordance with Subsection 551.03.

If the specified location and/or alignment tolerances are exceeded, the effect of the pile misalignment on the substructure design will be investigated. If the CO determines that corrective measures are necessary, implement suitable measures to correct the problem without compensation.

Place individual piles in pile groups, either starting from the center of the group and proceeding outward in both directions, or starting at the outside row and proceeding progressively across the group.

In an approved manner, correct all piles that are driven improperly, driven out of proper location, misaligned, or driven below the designated cutoff elevation. Replace piles damaged during handling or driving. Obtain approval for the proposed method(s) of correcting or repairing deficiencies.

Ensure that the method used in driving piles does not produce crushing and spalling of the concrete; injurious splitting, splintering, and brooming of the wood; or deformation of the steel.

(a) Timber Piles. Use piling that meets the minimum diameter requirements SHOWN ON THE DRAWINGS. Do not use piles with checks wider than ½ inch. Drive treated timber piles within 6 months after treatment. Handle and care for pressure-treated piles in accordance with American Wood Preservers Association (AWPA) standard M 4 and applicable portions of Subsection 557.04.

Install pile shoes as SHOWN ON THE DRAWINGS. Carefully shape the pile tip to secure an even, uniform bearing for the pile shoe. Fasten the shoe securely to the pile. Treat all holes, cuts, or daps in treated piles with two brush applications of creosote-coal tar solution or other preservative, as provided in the SPECIAL PROJECT SPECIFICATIONS.

Regulate the drop of the hammer to avoid damage to the pile if driving with a gravity hammer is permitted.

Select piles for any one bent to avoid undue bending or distortion of the sway bracing. Exercise care in the distribution of piles of various sizes to obtain uniform strength and rigidity in the bents of any given structure.

(b) Steel Piles. Furnish full length unspliced piles for lengths up to 60 feet. If splices are required in the first pile driven and it is anticipated that subsequent piles will also require splices, place the splices in the lower one-third of the pile. Splice lengths less than 10 feet are not permitted, and only two splices per pile are allowed, unless otherwise approved by the CO.

Load, transport, unload, store, and handle steel piles so that the metal is kept clean and free from damage. Do not use piles that exceed the camber and sweep permitted by allowable mill tolerance. Steel piles damaged during installation are considered

unsatisfactory unless load tests prove that the bearing capacity is 100 percent of the required ultimate capacity. Load tests performed will be at no cost to the Government.

(c) Precast & Prestressed Concrete Piles. Support concrete piles during lifting or moving at the points SHOWN ON THE DRAWINGS or approved shop drawings. If points are not shown, provide support at the quarter points. Provide slings or other equipment when raising or transporting concrete piles to avoid bending the pile or breaking edges.

Protect the heads of concrete piles with a pile cushion at least 4 inches thick. Cut the pile cushion to match the cross section of the pile top. Replace the pile cushion if it is either compressed more than one-half its original thickness or begins to burn. Provide a new pile cushion for each pile.

A concrete pile is defective if any defect is observed that will affect the strength or long-term performance of the pile.

(d) Concrete-Filled Pipe or Steel Shell Piles. Furnish and handle the steel shells or pipes in accordance with Subsection 551.09(b). Cutting shoes for shells or pipes may be inside or outside the shell. Use high-carbon structural steel with a machined ledge for shell bearing or cast steel with a ledge designed for attachment with a simple weld.

When practicable, drive all pile shells or pipes for a substructure unit prior to placing concrete in any of the shells or pipes. Do not drive pile shells or pipes within 15 feet of any concrete-filled pile shell or pipe until the concrete has cured for at least 7 days, or 3 days if using high-early-strength concrete. Do not drive any pile shell or pipe after it is filled with concrete.

Remove and replace shells that are determined to be unacceptable for use due to breaks, bends, or kinks.

551.10 Splices. Submit details for pile field splices for approval. Align and connect pile sections so the axis of the spliced pile is straight.

(a) Steel Piles. Submit a welder certification for each welder. Use welders certified for structural welding.

Make surfaces to be welded smooth, uniform, and free from loose scale, slag, grease, or other material that prevents proper welding. Steel may be oxygen cut. Carbon-arc gouging, chipping, or grinding may be used for joint preparation.

Weld in accordance with AASHTO/American Welding Society (AWS) D 1.5, Bridge Welding Code. Weld the entire pile cross section using prequalified AWS groove weld butt joints. Weld so there is no visual evidence of cracks, lack of fusion, undercutting, excessive piping, porosity, or inadequate size. Manufactured splices may be used in place of full penetration groove butt welds.

(b) Concrete Pile Splices. Submit drawings of proposed splices for approval. Use dowels or other acceptable mechanical means to splice precast concrete or precast prestressed

concrete piles. Ensure that the splice develops strengths in compression, tension, and bending equal to or exceeding the strength of the pile being spliced.

(c) Concrete Pile Extensions. Construct precast concrete piles and prestressed piles as shown below.

(1) Precast Concrete Piles. Extend precast concrete piles by removing the concrete at the end of the pile and leaving 40 diameters of reinforcement steel exposed. Remove the concrete to produce a face perpendicular to the axis of the pile. Securely fasten reinforcement of the same size as that used in the pile to the projecting reinforcing steel. Form the extension to prevent leakage along the pile.

Immediately before placing concrete, wet the top of the pile thoroughly and cover with a thin coating of neat cement, retempered mortar, or other approved bonding material. Place concrete of the same mix design and quality as that used in the pile. Keep forms in place for not less than 7 days after the concrete has been placed. Cure and finish in accordance with Section 552.

(2) Prestressed Piles. Extend prestressed precast piles in accordance with Subsection 551.10(c)(1). Include reinforcement bars in the pile head for splicing to the extension bars. Do not drive extended prestressed precast piles.

(d) Timber Piles. Do not splice timber piles.

551.11 Heaved Piles. Check for pile heave during the driving operation. Take level readings immediately after each pile is driven and again after piles within a radius of 15 feet are driven. Redrive all piles that heave more than ¼ inch. Redrive to the specified resistance or penetration. Continue readings until the CO determines that such checking is no longer required.

551.12 Pile Load Tests. Pile load tests are not required unless SHOWN ON THE DRAWINGS.

(a) Dynamic Load Test. Use a qualified pile specialty consultant with at least 3 years experience in dynamic load testing and analysis, to perform the dynamic load test, the Case Pile Wave Analysis Program (CAPWAP), and the wave equation analysis including the initial wave analysis specified in Subsection 551.03(b)(1). Submit a resume of the specialty consultant for approval by the CO.

Furnish a shelter to protect the dynamic test equipment from the elements. Locate the shelter within 50 feet of the test location. Provide a shelter with a minimum floor size of 64 square feet and minimum ceiling height of 7 feet. Maintain the inside temperature between 50°F and 95°F.

Furnish equipment and perform dynamic load tests in accordance with ASTM D 4945 under the supervision of the CO.

Place the piles designated as dynamic load test piles in a horizontal position and not in contact with other piles. Drill holes for mounting instruments near the head of the pile.

Mount the instruments and take wave speed measurements. Place the designated pile in the leads. Provide at least a 4-foot by 4-foot rigid platform, with a 42-inch safety rail, that can be raised to the top of the pile.

Provide a suitable electrical power supply for the test equipment. If field generators are used as the power source, provide functioning meters for monitoring power voltage and frequency.

Drive the pile to the depth at which the dynamic test equipment indicates that the required ultimate pile capacity is achieved. If necessary to maintain stresses in the pile below the values shown in Subsection 551.03(b)(2), reduce the driving energy transmitted to the pile by using additional cushions or reducing the energy output of the hammer. If nonaxial driving is indicated, immediately realign the driving system.

At least 24 hours after the initial driving, redrive each dynamic load test pile with instrumentation attached. Warm the hammer before redriving by applying at least 20 blows to another pile. Redrive the dynamic load test pile for a maximum penetration of 6 inches or a maximum of 50 blows, whichever occurs first. Practical driving refusal is defined as 15 blows per inch for steel piles, 8 blows per inch for concrete piles, and 5 blows per inch for timber piles.

Verify the assumptions used in the initial wave equation analysis submitted in accordance with Subsection 551.03(b) using CAPWAP. Analyze one blow from the original driving and one blow from the redriving for each pile tested.

Perform additional wave equation analyses with adjustments based on the CAPWAP results. Provide a graph showing blow count versus ultimate capacity. For open-end diesel hammers, provide a blow count versus stroke graph for the ultimate capacity. Provide the driving stresses, transferred energy, and pile capacity as a function of depth for each dynamic load test.

Based on the results of the dynamic load testing, CAPWAP analyses, and wave equation analyses, the production driving criteria may be approved by the CO, who will provide the order list and the required cutoff elevations, or additional pile penetration and testing may be specified. This information will be provided within 10 days after receipt of all required test data for the test piles driven.

(b) Static Load Tests. Perform static load tests in accordance with ASTM D 1143 using the quick load test method, except as modified herein. Submit drawings of the proposed loading apparatus for approval by the CO, in accordance with the following:

(1) Have a licensed professional engineer prepare the drawings.

(2) Furnish a loading system capable of applying 150 percent of the ultimate pile capacity or 1,000 tons, whichever is less.

(3) Construct the apparatus to allow increments of load to be placed gradually without causing vibration to the test pile.

When tension (anchor) piles are required, drive tension piles at the location of permanent piles when feasible. Do not use timber or tapered piles installed in permanent locations as tension piles. Take the test to plunging failure or the capacity of the loading system.

The safe axial pile load is defined as 50 percent of the failure load. The failure pile load is defined as follows:

- For piles 24 inches or less in diameter or diagonal width:

$$S_f = S + (0.15 + 0.008D)$$

- For piles greater than 24 inches in diameter or diagonal width:

$$S_f = S + \frac{D}{30}$$

where

S_f = settlement at failure in inches
D = pile diameter or diagonal width in inches
S = elastic deformation of pile in inches

Determine top elevation of the test pile immediately after driving and again just before load testing to check for heave. Wait a minimum of 3 days between the driving of any anchor or the load test piles and the commencement of the load test. Prior to testing, redrive or jack to the original elevation any pile that heaves more than ¼ inch.

After completion of static testing, remove or cut off any test or anchor piling not a part of the finished structure at least 2 feet below either the bottom of the footing or the finished ground elevation.

Based on the results of the static load testing, the production driving equipment may be approved by the CO, who will provide the order list and the required cutoff elevations, or additional tests may be specified. This information will be provided within 10 days after receipt of all required test data for the test piles driven.

551.13 Pile Cutoffs. Cut off the tops of all production piles and pile casings at the required elevation. Cut off the piles clean and straight parallel to the bottom face of the structural member in which they are embedded.

Ensure full bearing between timber caps and piles by making accurate, square cuts.

Remove all unused pile cutoff lengths and dispose of them in accordance with applicable State and local laws and regulations. Dispose of treated timber pile cutoffs in accordance with the requirements of Subsection 202.04(a) for disposal of treated material.

(a) Steel Piles. Do not paint steel to be embedded in concrete. Before painting the exposed steel pile, thoroughly clean the metal surface of any substance that will inhibit paint adhesion. Paint in accordance with Section 563. Paint portions of completed trestle or other exposed piling to a point not less than 3 feet below finished ground line or to the waterline, as SHOWN ON THE DRAWINGS or as provided in the SPECIAL PROJECT SPECIFICATIONS.

(b) Wood Piles. When possible, cut the top of the pile on a bevel. Treat the heads of all treated timber piles that are not embedded in concrete using one of the following methods:

(1) Where possible, reduce the moisture content of the wood to no more than 25 percent and allow no free moisture on the surface. Brush on one application of creosote-coal tar solution as required in AWPA standards, or preservatives as provided in the SPECIAL PROJECT SPECIFICATIONS.

(2) Build up a protective cap by applying alternate layers of loosely woven fabric and hot asphalt or tar similar to membrane waterproofing, using three layers of asphalt or tar and two layers of fabric. Use fabric at least 6 inches wider in each direction than the diameter of the pile. Turn the fabric down over the pile and secure the edges by binding with two turns of No. 10 galvanized wire. Apply a final layer of asphalt or tar to cover the wire. Neatly trim the fabric below the wires.

(3) Cover the sawed surface with three applications of a hot mixture of 60 percent creosote and 40 percent roofing pitch, or thoroughly brush coat with three applications of hot creosote and cover with hot roofing pitch.

551.14 Unsatisfactory Piles. Correct unsatisfactory piles using an approved method. Methods of correcting unsatisfactory piles may include one or more of the following:

(a) Using the pile at a reduced capacity.

(b) Installing additional piles.

(c) Repairing damaged piles.

(d) Replacing damaged piles.

(e) Splicing on additional length(s) and driving, when necessary.

(f) Building up pile(s).

551.15 Placing Concrete in Steel Shell or Pipe Piles. After driving, clean the inside of shells and pipes by removing all loose material. Keep the shell or pipe substantially watertight. Provide suitable equipment for inspecting the entire inside surface of the driven shell or pipe just before placing concrete.

(a) Reinforcing Steel. When reinforcing steel is required, make the spacing between adjacent cage elements at least 5 times the maximum size of aggregate in the concrete.

Securely tie concrete spacers or other approved spacers at fifth points around the perimeter of the reinforcing steel cage. Install spacers at intervals not to exceed 10 feet measured along the length of the cage.

Place the reinforcement cage into the driven shell or pipe when the concrete reaches the lower limits of the reinforcement. Support the reinforcement so it remains within 2 inches of the required vertical location. Support the cage from the top until the concrete reaches the top of the pile.

(b) Concrete. Construct concrete in accordance with Section 552. Place concrete in one continuous operation from the bottom to the top of the pile. Before the initial concrete set, consolidate the top 10 feet of the concrete pile using approved vibratory equipment.

Measurement

551.16 Method. Use the method of measurement that is DESIGNATED IN THE SCHEDULE OF ITEMS.

Measure piles by the linear foot or by the each. When measurement is by the linear foot, measure the length of pile from the cutoff elevation rounded to the tip.

Measure pile load tests by the each or by the lump sum.

Measure preboring by the linear foot.

Measure splices by the each for those made as required to drive piling in excess of the estimated plan tip elevation.

Measure test piles and pile shoes by the each.

Payment

551.17 Basis. The accepted quantities will be paid for at the contract unit price for each PAY ITEM DESIGNATED IN THE SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item		**Pay Unit**
551(01)	_____ piles, furnished	Linear Foot
551(02)	_____ piles, driven	Linear Foot
551(03)	_____ piles, furnished	Each

551(04) _____ piles, driven.....Each

551(05) _____ pile load test.....Each

551(06) _____ pile load test.....Lump Sum

551(07) Preboring.....Linear Foot

551(08) Splices.....Each

551(09) Test piles.....Each

551(10) Pile shoes.....Each

Section 552 - Structural Concrete

Description

552.01 Work. Furnish, place, finish, and cure concrete in bridges, culverts, and other structures.

Structural concrete class is designated as shown in Table 552-1.

Table 552-1. - Composition of concrete.

Class of Concrete	Minimum Cement Content lb/yd^3	Maximum W/C Ratio	Slump[a] inch	Minimum Air Content[b] (%)	Course Aggregate AASHTO M 43
A	611	0.49	2 to 4	-	No. 57
A(AE)	611	0.44	1 to 4	5.0	No. 57
C	658	0.49	2 to 4	-	No. 7
C(AE)	658	0.44	1 to 3	6.0	No. 7
P	658	0.44	0 to 4	-	No. 67
Seal	658	0.54	4 to 8	-	No. 57

[a.] Maximum slump is 8 inches if approved mix design includes a high-range water reducer.
[b.] See Subsection 552.03 for maximum air content.

Materials

552.02 Requirements. Furnish material that conforms to specifications in the following subsections:

Air-Entraining Admixtures 711.02
Boiled Linseed Oil 725.14
Chemical Admixtures 711.03
Coarse Aggregate 703.02
Color Coating 725.23
Curing Material 711.01
Elastomeric Bearing Pads 717.10
Elastomeric Compression Joint Seals 717.16
Epoxy Resin Adhesives 725.21
Fine Aggregate.....703.01
Fly Ash 725.04
High-Strength Nonshrink Grout 701.02
Latex Modifier 711.04
Low-Strength Grout.....701.03
Mortar 701.04
Portland Cement 701.01
Sealants, Fillers, Seals, & Sleeves 712.01
Water.....725.01

Construction

552.03 Composition (Concrete Mix Design). Design and produce concrete mixtures that conform to Table 552-1 for the class of concrete specified and the minimum strength requirements as SHOWN ON THE DRAWINGS or in Subsection 552.04. Determine design strength values in accordance with ACI 214. Ensure that structural concrete also conforms to the following ACI specifications:

- ACI 211.1 for normal and heavyweight concrete.
- ACI 211.2 for lightweight concrete.
- ACI 211.3 for no-slump concrete.

Submit written concrete mix designs for approval at least 30 days before production. Include the following in each mix design submittal:

(a) Project identification.

(b) Name and address of Contractor and concrete producer.

(c) Mix design designation.

(d) Class of concrete and intended use.

(e) Material proportions.

(f) Name and location of material sources for aggregate, cement, admixtures, and water.

(g) Type of cement and type of cement replacement, if used. Fly ash, ground iron blast-furniture slag, or silica fume may partially replace cement as follows in any mix design except for prestressed concrete:

(1) Fly ash.

(a) Class F. Not more than 20 percent of the minimum weight of Portland cement in Table 552-1 may be replaced with Class F fly ash at the rate of 1.5 parts fly ash per 1 part cement.

(b) Class C. Not more than 25 percent of the minimum mass of Portland cement in Table 552-1 may be replaced with Class C fly ash at the rate of 1 part fly ash per 1 part cement.

(2) Ground iron blast-furnace slag. Not more than 50 percent of the minimum mass of Portland cement in Table 552-1 may be replaced with ground iron blast-furnace slag at the rate of 1 part slag per 1 part cement.

(3) Silica fume (microsilica). Not more than 10 percent of the minimum mass of Portland cement in Table 552-1 may be replaced with silica fume at the rate of 1 part silica fume per 1 part cement.

The water/cement ratio for modified concrete is the ratio of the mass of water to the combined masses of Portland cement and cement substitute.

(h) Cement content in pounds per cubic yard of concrete.

(i) The saturated surface dry batch weight of the coarse and fine aggregate in pounds per cubic yard of concrete.

(j) Water content (including free moisture in the aggregate plus water in the drum, exclusive of absorbed moisture in the aggregate) in pounds per cubic yard of concrete.

(k) Target water/cement ratio.

(l) Dosage of admixtures. Entrained air may be obtained either by the use of an air-entraining Portland cement, or by the use of an air-entraining admixture. Do not use set-accelerating admixtures with Class P (prestressed) concrete. Do not mix chemical admixtures from different manufacturers.

(m) Sieve analysis of fine and coarse aggregate.

(n) Absorption of fine and coarse aggregate.

(o) Bulk specific gravity (dry and saturated surface dry) of fine and coarse aggregate.

(p) Dry rodded unit mass of coarse aggregate in pounds per cubic yard.

(q) Fineness modulus (FM) of fine aggregate.

(r) Deleterious substances (coarse and fine aggregate); clay lumps and friable particles; material finer than the No. 200 sieve; coal and lignite (AASHTO M 80 7.1.6); chert (coarse aggregate only); and organic impurities (fine aggregate only).

(s) Evaluation of potential aggregate reactivity.

(t) Percentage of wear (L.A.R.) for coarse aggregate only.

(u) Sand equivalent (fine aggregate only).

(v) Material certifications for cement, admixtures, and aggregate.

(w) TV's for concrete slump with and without high-range water reducers.

(x) TV's for concrete air content. Include the proposed range of air content for concrete to be incorporated into the work. Describe the methods by which air content will be monitored and controlled. Provide acceptable documentation that the slump and compressive strength of the concrete are within specified limits throughout the full range of proposed air content. In the absence of such acceptable documentation, ensure that the maximum air content is 10 percent.

(y) Concrete unit mass.

(z) Compressive strengths of 7- and 28-day concrete. Pending 28-day strength results, a mix design may be approved on the basis that the 7-day compressive strength results equal or exceed 85 percent of the minimum strength requirements, when no accelerators or early strength cements are used.

(aa) Material samples, if requested.

Use a testing laboratory that is fully equipped and capable of performing the required tests and services. Base the mix design on representative samples of aggregates, cement, water, and admixtures to be used on the project. Take aggregate samples in accordance with AASHTO T 2 and reduce to testing size in accordance with AASHTO T 248. Submit a separate proposed mix design for each class of concrete to the CO for review.

Current mix designs for other projects may be acceptable, provided that all items required herein are covered by certified submittals. Ensure that mix design and aggregate quality tests from other projects have been run within 12 months of the date of submittal, and that the aggregate source is the same.

Begin production only after the mix design is approved.

Furnish a new mix design for approval if there is a change in a source of material, or when the FM of the fine aggregate changes by more than 0.20.

Use Type II cement for all classes of concrete, but use Type III cement when concrete work is permitted by the CO in air temperatures below 35 °F. Type III cement may be used in Class A and seal concrete with the approval of the CO. Type III cement may be used in Class P concrete when documented in the approved mix design.

552.04 Concrete Compressive Strength. Use the minimum 28-day compressive strength for the given classes of concrete shown in Table 552-2, unless otherwise SHOWN ON THE DRAWINGS.

Table 552-2. - Specified minimum concrete strength (PSI).			
Concrete Class	**At Time of Transfer of Prestress Force**	**7 – Day**	**28 - Day**
A & A(AE)	-	2,300	3,500
C & C(AE)	-	2,600	4,000
P	4,500	-	5,800
P (AE)	4,500	-	5,000
Seal	-	2,000	3,000

Make two standard test specimens for a strength test. Take enough specimens to make at least one 7-day strength test and one 28-day strength test (a minimum total of four specimens) for each structural element. Use the average of the strengths of the two specimens for test result, but discard any specimen that shows definite evidence, other than low strength, of improper sampling, molding, handling, curing, or testing, and consider the strength of the remaining cylinder to be the test result.

Extend the standard 28-day curing period for compressive strength tests for fly-ash modified concrete by 1 day (rounded to the nearest whole day) for each 1.5 percent of Portland cement replaced with fly ash at the selected rate. (Example: If the maximum of 20 percent cement is replaced, the curing period for cylinders is 41 days.)

552.05 Storage & Handling of Material. Store and handle all material in a manner that prevents segregation, contamination, or other harmful effects. Do not use cement and fly ash containing evidence of moisture contamination. Store and handle aggregate in a manner that ensures a uniform moisture content at the time of batching.

Obtain the CO's approval before using cement that has been stored on the site for more than 60 days. Provide separate storage of cement that is of different blends, types, or from different mills.

552.06 Measuring Material. Batch the concrete in accordance with the approved mix design and the following tolerances:

Cement .....± 1%
Water .....± 1%
Aggregate .....± 2%
Additive .....± 3%

Submit to the CO, for approval, a written procedure for adding the specified amount of admixture. Provide separate scales for the admixtures that are to be proportioned by mass and accurate measures for those to be proportioned by volume.

A calibrated volumetric system may be used if the specified tolerances are maintained.

552.07 Batching Plant, Mixers, & Agitators. Use a batching plant, mixer, and agitator conforming to AASHTO M 157. Use continuous volumetric mixing equipment that conforms to AASHTO M 241.

552.08 Mixing. Mix the concrete in a central-mix plant or in truck mixers. Operate all equipment within manufacturer's recommended capacity. Produce concrete of uniform consistency.

(a) Central-Mix Plant. Dispense liquid admixtures through a controlled flowmeter. Use dispensers with sufficient capacity to measure, at one time, the full quantity of admixture required for each batch. If more than one admixture is used, dispense each with separate equipment.

Charge the coarse aggregate, one-third of the water, and all air-entraining admixture into the mixer first, then add remainder of the material.

Mix for at least 50 seconds. Begin mixing time after all cement and aggregate are in the drum. Add the remaining water during the first quarter of the mixing time. Add 4 seconds to the mixing time if timing starts the instant the skip reaches its maximum raised position. Transfer time in multiple-drum mixers is included in mixing time. Mixing time ends when the discharge chute opens.

Remove the contents of an individual mixer before a succeeding batch is charged into the drum.

(b) Truck Mixer. Do not use mixers with any section of the blades worn 1 inch or more below the original manufactured height. Do not use mixers and agitators with accumulated hard concrete or mortar in the mixing drum.

Add admixtures to the mix water before or during mixing.

Charge the batch into the drum so a portion of the mixing water enters in advance of the cement.

Mix each batch of concrete not less than 70 or more than 100 revolutions of the drum or blades at mixing speed. Begin the count of mixing revolutions as soon as all material, including water, is in the mixer drum.

Do not allow the sum of all drum revolutions at both mixing and agitating speeds to exceed 300 before all concrete has been discharged from the drum; but ensure that the sum of all drum revolutions does not exceed 200 if the outside air temperature is over 85 °F. If mixing is done before arrival of the truck at the point of delivery, rotate the drum at mixing speed for 10 to 15 revolutions to reblend possible stagnant spots.

If set-retarding admixture is used, do not allow the sum of all drum revolutions at both mixing and agitating speeds to exceed 550 before all concrete has been discharged from the drum; but ensure that the sum of all drum revolutions does not exceed 450 if the outside air temperature is over 85 °F.

Do not hand mix except in case of emergency and with the written approval of the CO. When permitted, perform only on watertight platforms. Do not exceed 1/4 yd^3 volume for

hand mixed batches. Do not permit hand mixing for concrete that is to be placed under water.

552.09 Delivery. Submit a written schedule of concreting operations, including scheduling, personnel, and equipment, when requested by the CO. Provide the CO 24-hour notice prior to placing any concrete.

Produce and deliver concrete to permit a continuous placement. Do not permit concrete to achieve initial set before the remaining concrete is placed adjacent to it. Never allow the time interval between placement to exceed 30 minutes. Use methods of delivering, handling, and placing that will minimize rehandling of the concrete and prevent any damage to the structure.

Do not place concrete that has developed an initial set. Never retemper concrete by adding water.

(a) Truck Mixer/Agitator. Use the agitating speed for all rotation after mixing. When a truck mixer or truck agitator is used to transport concrete that is completely mixed in a stationary central construction mixer, mix during transportation at manufacturer's recommended agitating speed.

Water and admixtures (if in the approved mix design) may be added at the project to obtain the required slump or air content, provided that the total of all water in the mix does not exceed the maximum water/cement ratio. If additional water is necessary, add only once and remix with 30 revolutions at mixing speed. Complete the remixing within 45 minutes (75 minutes for Type I, IA, II, or IIA cements with water-reducing or retarding admixture) after the initial introduction of the mixing water to the cement or the cement to the aggregates.

After the beginning of the addition of the cement, complete the discharge of the concrete within the time specified in Table 552-3, unless otherwise approved by the CO or as allowed by the SPECIAL PROJECT SPECIFICATIONS.

(b) Nonagitating Equipment. Nonagitating equipment may be used to deliver concrete if the concrete discharge is completed within 20 minutes from the beginning of the addition of the cement to the mixing drum. Use equipment with smooth, mortar tight, metal containers capable of discharging the concrete at a controlled rate without segregation. Provide covers when needed for protection.

Table 552-3. - Concrete discharge time limits.

Cement Type With and Without Admixtures	Time Limit (h)	
	≤ 85 °F	> 85 °F
Type I, IA, II, or IIA	1.5	1.00
Type I, IA, II, or IIA with water-reducing or water–retarding admixture	2.00	1.50
Type III	1.25	0.75
Type III with water-reducing or water–retarding admixture	1.75	1.25

Note: Temperatures are ambient air measured on formwork.

552.10 Quality Control of Mix. Submit and follow a quality control plan for the following:

(a) Mixing. Designate a competent and experienced concrete technician to be at the mixing plant in charge of the mixing operations and to be responsible for the overall quality control, including:

(1) The proper storage and handling of all components of the mix.

(2) The proper maintenance and cleanliness of plant, trucks, and other equipment.

(3) The gradation testing of fine and coarse aggregates.

(4) The determination of the FM of fine aggregate.

(5) The measurement of moisture content of the aggregates and adjustment of the mix proportions, as required before each day's production, or more often if necessary, to maintain the required water/cement ratio.

(6) The computation of the batch weights for each day's production and the checking of the plant's calibration as necessary.

(7) The completion of batch tickets. Include the following information:

(a) Concrete supplier.

(b) Ticket serial number.

(c) Date and truck number.

(d) Contractor.

(e) Structure or location of placement.

(f) Mix design and concrete class.

(g) Component quantities and concrete total volume.

(h) Moisture corrections for aggregate moisture.

(i) Total water in mix at plant.

(j) Time of batching and time at which discharge must be completed.

(k) Maximum water that may be added to the mix at the jobsite.

Provide equipment necessary for the above tests and controls. Furnish copies of work sheets for items (3), (4), (5), and (6) as they are completed.

(b) Delivery & Sampling. Designate at least one competent and experienced concrete technician to be at the project and be responsible for concrete delivery, discharge operations, and sampling, including:

(1) The verification that adjustments to the mix before discharge comply with the specifications.

(2) The completion of the batch ticket, the recording of the apparent water/ cement ratio, and the time discharge is completed. Furnish a copy of each batch ticket at the time of placement.

(3) The furnishing of all equipment and the performance of temperature, unit weight, air content, slump, and other tests to verify specification compliance before and during each placement operation.

Sample every batch after at least 1/4 yd^3 are discharged and before placing any of the batch in the forms. When continuous mixing is used, sample approximately every 10 yd^3. Test the air content in accordance with AASHTO T 152 or T 196, and evaluate the result based on a single test or the average of two tests.

Test slump and temperature of each batch in accordance with AASHTO T 119 and AASHTO T 152 or T 196.

If three successive samples are tested and compliance with the specifications is indicated, screening tests may be reduced to a frequency approved by the CO. Resume initial testing frequency if a test shows a failing temperature, air content, or slump, or when directed.

If there is no prior experience with the approved mix design or if special handling procedures, such as pumping, change one or more of the characteristics between discharge of the load and placement in the forms, correlate the discharge tests

with the placement tests to define these changes. Provide documentation. Repeat the correlations as often as necessary or as directed.

(4) The taking of samples for strength tests in accordance with AASHTO T 141 and T 23 from batches specified by the CO. Composite samples are not required. The point of sampling is from the discharge stream at the point of placement. Provide cylinder molds. Make compressive strength test cylinders as directed by the CO, provide the appropriate initial curing, and carefully transport the cylinders to the jobsite curing facility. Cylinders will be used for 28-day breaks, verification, projected strengths, or other purposes specified. Assist in the performing of other tests as requested.

***(c) Testing*.** Determine compressive strength of concrete test cylinders in accordance with AASHTO T 22, and of drilled concrete cores in accordance with AASHTO T 24.

Ensure that the average of all the strength tests representing the concrete in each structural element meets the following requirements:

(1) For concrete in structures designed by the service load method, when seven or more strength tests are available, not more than 20 percent of the strength tests shall have values less than the specified strength, and the average of any six consecutive strength tests shall be equal to or greater than the specified strength. This paragraph does not apply to designs by the strength method where the service load method was used to check fatigue and crack control.

(2) For concrete in structures designed by the strength method and in all prestressed members, when seven or more strength tests are available, not more than 10 percent of the strength tests shall have values less than the specified strength, and the average of any three consecutive strength tests shall be equal to or greater than the specified strength. In applying this requirement to prestressed members, the strength tests performed on all similar members, such as all beams, shall be grouped together for purposes of counting the number of tests available. This paragraph also applies to designs by the strength method where the service load method was used to check fatigue and crack control.

If six or fewer strength tests are available, the average of all the tests shall be equal to or greater than the strengths shown in the following:

Number of Strength Tests	Required Average Strength (% of specified strength)	
	Class A, C, & Seal	Class P
1	79	86
2	90	97
3	94	102
4	97	105
5	99	107
6	100	108

If the concrete strength tests fail to meet the requirements of this specification, the CO may order the Contractor to have a testing laboratory that is acceptable to the Forest Service take and test core samples of questionable concrete. The CO may order all low-strength concrete removed and replaced if core strengths are below specified strengths. All costs connected with concrete coring and removal and replacement of concrete that fails to meet these requirements shall be borne by the Contractor.

552.11 Field Adjustment of Concrete Mix. Field adjustment of the concrete mix designs will be necessary to compensate for the free-water content in the aggregates.

After initial mixing, if the consistency (slump) is outside the specification limits (Table 552-l) by less than 1 inch, the CO may approve the addition of water or cement, provided all that the following conditions are met:

(a) Addition of Water. Water may be added, provided that:

(1) The maximum allowable water content in pounds per cubic yard of concrete (Table 552-1) is not exceeded.

(2) The maximum allowable mixing time (or number of drum revolutions) is not exceeded.

(3) Concrete is remixed for at least half of the minimum mixing time (or number of drum revolutions).

(b) Addition of Cement. Cement may be added, except to Class P concrete, provided that:

(1) The amount of cement added does not exceed 94 lbs/yd^3 more than the mix design or a total of 705/yd^3, unless otherwise DESIGNATED IN THE SPECIAL PROJECT SPECIFICATIONS.

(2) The maximum allowable mixing time (or number of drum revolutions) is not exceeded.

(3) Concrete is remixed for at least half of the minimum mixing time (or number of drum revolutions).

(c) Adjustment for Percent Entrained Air. Vary the amount of air-entraining admixture used in each batch as necessary from that given in the approved mix design to produce concrete with the percent entrained air specified in Table 552-1.

552.12 Temperature and Weather Conditions. Maintain the temperature of the concrete mixture just before placement between 50 °F and 90 °F; except maintain the concrete for bridge decks between 50 °F and 77 °F.

(a) Cold Weather. Cold weather is defined as any time during the concrete placement or curing period that the ambient temperature at the worksite drops below 35 °F or the ambient temperature at the site drops below 50 °F for a period of 12 hours or more.

When cold weather is reasonably expected or has occurred within 7 days of anticipated concrete placement, submit a detailed plan for producing, transporting, placing, protecting, curing, and temperature monitoring of concrete during cold weather. Include procedures for accommodating abrupt changes in weather conditions. Do not commence placement until plan is approved. Approval of an acceptable plan will take at least 1 day.

Before commencing cold weather concreting, have all material and equipment required for protection available at or near the project and subject to the approval of the CO.

Remove all snow, ice, and frost from the surfaces, including reinforcement and subgrade, against which the concrete is to be placed. Ensure that the temperature of any surface that will come into contact with fresh concrete is at least 35 °F and is maintained at a temperature of 35 °F or above during the placement of the concrete.

Place heaters and direct ducts so as not to cause concrete drying or fire hazards. Vent exhaust flue gases from combustion heating units to the outside of any enclosures. Heat the concrete components in a manner that is not detrimental to the mix. Do not heat cement or permit the cement to come into contact with aggregates that are hotter than 100 °F. Ensure that concrete at the time of placement is of uniform temperature and free of frost lumps. Do not heat aggregates with a direct flame or on sheet metal over fire. Do not heat fine aggregate by direct steam. Do not add salts to prevent freezing.

Provide heat within the housing by steam or hot air. Maintain a humid condition within the housing during the heating period. Do not use stoves or open-burning salamanders within the housing.

Do not use any heating method that will endanger forms, falsework, or any part of the structure, or that will subject the concrete to drying out or other injury due to excessive temperatures. Do not allow the concrete deck surface temperature to exceed 90 °F throughout the curing period.

Maintain a reasonably uniform temperature within the enclosure throughout the curing period.

Provide adequate fire protection when heating is in progress, and maintain watchmen or other attendants to keep heating units in continuous operation.

Furnish and place continuously recording surface temperature measuring devices that are accurate within ± 2 °F.

Make outside air temperature recordings at the same time that recordings are made within the enclosure. Provide a copy of temperature records to the CO.

During cold weather, protect the concrete for at least 7 days at or above the minimum temperatures shown in Table 552-4.

Table 552-4. - Cold weather concrete surface temperatures.

Concrete Surface Temperatures	Minimum Section Size Dimension (inches)			
	< 12	**12 – 36**	**36 – 72**	**>72**
Minimum Temperature during protection period	55 °F	50 °F	45 °F	40 °F
Maximum allowable temperature drop in any 24–hour period after end of protection	50 °F	40 °F	30 °F	20 °F

When pozzolan or fly ash cement is used, adjust the required period of controlled temperature and moisture as follows:

Percentage of Cement Replaced by Weight	Required Period of Controlled Temperature and Moisture
10%	9 days
10–15%	10 days
16–20%	11 days

The above requirement for an extended period of controlled temperature and/or moisture may be waived if a compressive strength of 65 percent of the specified 28-day strength is achieved in 7 days.

At the end of the protection period, allow the concrete to cool gradually over 24 hours at a rate not to exceed the maximum values shown in Table 552-4. All protection may be removed when the concrete surface temperature is within 25 °F of the ambient air temperature.

If the concrete temperatures cannot be maintained within the limits specified in Table 552-4 through insulated forms or blankets, enclose each section of the structure with adequate housing before placing the concrete in the section.

Make the protective housing of sufficient size to allow all concrete placing and finishing operations for any one placement to proceed under cover without hindrance. However, to facilitate the placement of concrete, install the covering material immediately after depositing the concrete. Construct the housing to be weather tight and in a manner that will ensure that specified temperatures will be maintained uniformly throughout the enclosure during the protection period.

When housing of the structure is not initially installed, but may be subsequently required in accordance with the specifications, protect structural concrete in bridge decks or similar thin sections with insulating blankets or other methods approved by the CO. Ensure that the curing method prevents moisture loss on all exposed surfaces, including those protected by insulating blankets.

Provide insulation that consists of bats or blankets of fiberglass, rock wool, balsam wool, insulation boards, or other approved material.

Completely encase the bats or blankets in suitable wind- and water-resistant covers that are be fastened securely to wood forms between the studs and walls, with edges and ends

sealed to the framing to minimize heat loss. Attach insulation to steel forms by adhesive or other approved methods. Cover ribs and flanges of steel forms with insulating blankets or separate strips of insulation. Ensure that the edges and corners of concrete are well insulated. Protect horizontal surfaces of concrete with a layer of the insulating material securely fastened in place. Protect the tops of placements, such as bridge decks and similar flat slab sections, with tarpaulins over the insulation. Cover large insulating blankets around and securely fasten in place for curing concrete columns cast in prefabricated forms and similar concrete items. Seal all joints in the blankets with tape.

Use electric heating blankets and other suitable materials instead of insulated blankets or bats only when specifically approved by the CO for each application.

Assume entire responsibility for the proper protection and final satisfactory condition of all concrete placed during cold weather or exposed to cold weather within the required protection period. Remove and replace any concrete that has been frozen or damaged due to other causes.

(b) Hot Weather. Hot weather is defined as any time during the concrete placement that the ambient temperature at the work site is above 95 °F.

In hot weather, cool all surfaces that will come in contact with the mix to below 95 °F. Cool by covering with wet burlap or cotton mats, fog spraying with water, covering with protective housing, or using other approved methods.

Immediately prior to and during placement, maintain concrete at a temperature not to exceed 95 °F; but ensure that bridge superstructure (deck) concrete does not exceed a temperature of 78 °F.

When placing concrete deck slabs, if the air temperature near the slab's surface is expected to rise above 78 °F, schedule operations so that finishing of the top of the slab is completed before this occurs, or use hot-weather concreting practices to maintain the deck surface temperature at 78 °F or less until finishing is completed.

Maintain concrete temperature by using any combination of the following methods:

(1) Shade the material storage areas or production equipment.

(2) Cool aggregate by sprinkling.

(3) Cool aggregate and/or water by refrigeration or replace a portion or all of the mix water with flaked or crushed ice to the extent that the ice will completely melt during mixing of the concrete.

(c) Evaporation. When placing concrete in bridge decks or other exposed slabs, limit the expected evaporation rate to less than 0.1 lb/ft^2/hour (0.5 kg/m^2/h) as determined by Figure 552-1 or the following:

$$EVAP = \frac{1 + 0.2374WV}{2{,}906} \times \left[CT^2 - 4.762CT + 220.8 - RH \times \left[\frac{AT^3 + 127.8AT^2 + 665.6AT + 34{,}283}{20{,}415} \right] \right]$$

where

$EVAP$ = evaporation rate (kg/m^2/h)
WV = wind velocity (km/h)
RH = relative humidity (%)
AT = air temperature (°C)
CT = concrete temperature (°C)

When necessary, take one or more of the following actions:

(1) Construct windbreaks or enclosures to effectively reduce the wind velocity throughout the area of placement and for a period of 12 hours following completion of the deck placement or until evaporation rate is less than 0.10 pounds per square foot per hour (0.5 kg/m^2/h).

(2) Use fog sprayers upwind of the placement operation to effectively increase the relative humidity.

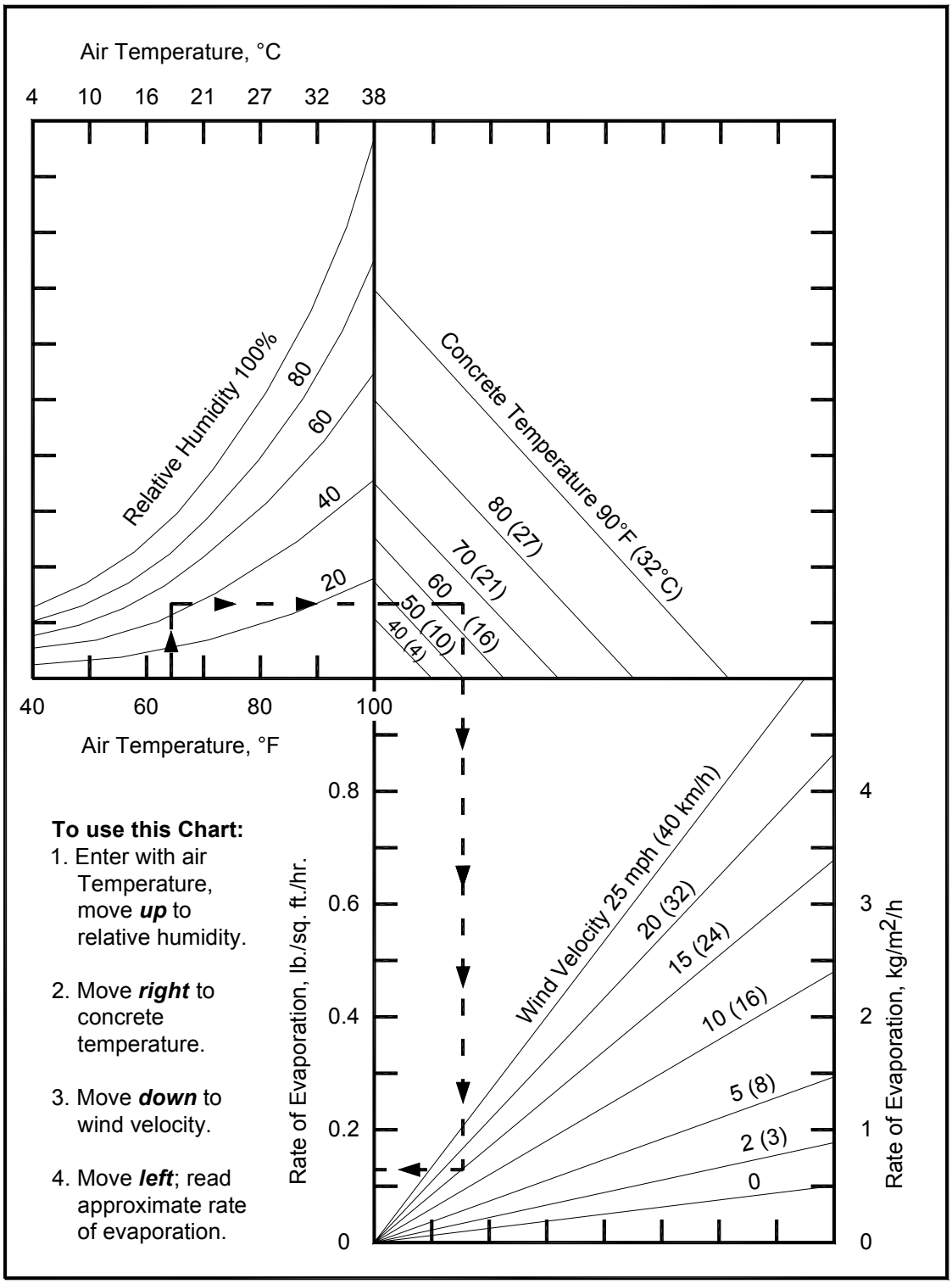
(3) Reduce the temperature of the concrete in accordance with Subsection 552.12(b).

(d) Rain. At all times during and immediately after placement, protect the concrete from rain.

552.13 Handling & Placing Concrete. Perform the work specified in Section 206. Construct reinforcing steel, structural steel, bearing devices, joint material, and miscellaneous items in accordance with the appropriate sections.

(a) General. Use falsework and forms in accordance with Section 562. Handle, place, and consolidate concrete using methods that will not cause segregation and will result in dense, homogeneous concrete that is free of voids and rock pockets. Use placement methods that do not cause displacement of reinforcing steel or other material that is embedded in the concrete. Place and consolidate concrete before initial set. Do not retemper concrete by adding water to the mix except as provided for in Subsection 552.11.

Do not place concrete until the forms, all embedded material, and the adequacy of the foundation material have been inspected and approved by the CO.



Note: Example shown by dashed lines is for an air temperature of 65 °F (18 °C), relative humidity of 45%, concrete temperature of 65 °F (18 °C), and a wind velocity of 15 mph (24 km/h). This results in a rate of evaporation of 0.13 lbs/ft^2/hr (0.64 kg/m^2/hr).

Figure 552-1. - Evaporation rate of surface moisture

Remove all mortar, debris, and foreign material from the forms and reinforcing steel before commencing placement. Thoroughly moisten the forms and subgrade immediately before concrete is placed against them. Temporary form spreader devices may be left in place until concrete placement precludes their need. Remove them when no longer needed.

Place concrete continuously without interruption between planned construction or expansion joints. Ensure that the delivery rate and placing sequence and methods are such that fresh concrete is always placed and consolidated against previously placed concrete before initial set has occurred in the previously placed concrete. Do not allow the time between the placement of successive batches to exceed 30 minutes (20 minutes under hot weather conditions).

During and after placement of concrete, do not damage previously placed concrete or break the bond between the concrete and reinforcing steel. Keep workers off fresh concrete. Do not support platforms for workers and equipment directly on reinforcing steel. After the concrete is set, do not disturb the forms or reinforcing bars that project from the concrete until it is of sufficient strength to resist damage.

Five to 10 working days before placing concrete in a cast-in-place bridge deck; hold a preplacement conference to discuss the construction procedures, personnel, and equipment to be used. At this time, provide full details on plans for the placement operation, including finishing machine data, workforce, contingency plans, concrete delivery, and other information requested by the CO.

(b) Sequence of Placement. Observe the following sequence of placement:

(1) Substructures. Do not place loads on finished bents, piers, or abutments until concrete strength cylinder tests from the same concrete cured under the same conditions as the substructure element indicate that all concrete has at least 80 percent of its required 28-day compressive strength.

(2) Vertical Members. For vertical members more than 15 feet in height, allow the concrete to set for at least 4 hours before placing concrete for integral horizontal members. For vertical members less than 15 feet in height, allow the concrete to set for at least 30 minutes. Do not apply loads from horizontal members until the vertical member has attained its required strength.

(3) Superstructures. Do not place concrete in the superstructure until substructure forms have been stripped sufficiently to determine the acceptability of the supporting substructure concrete. Do not place concrete in the superstructure until the substructure has attained the required strength.

Place concrete for T-beams in two separate operations. Wait at least 5 days after stem placement before placing the top deck slab concrete.

Concrete for box girders may be placed in two or three separate operations consisting of bottom slab, girder webs, and top slab, or as SHOWN ON THE DRAWINGS. However,

place the bottom slab first, and do not place the top slab until the girder webs have been in place for at least 5 days.

(4) Arches. Place concrete in arch rings so that the centering is loaded uniformly and symmetrically.

Place centering upon approved jacks to provide means of correcting any slight settlement that may occur after concrete placement has begun. Make any adjustments made necessary by settlement before the concrete has taken its initial set.

(5) Box Culverts. Place the base slab of box culverts and allow to set 24 hours before the remainder of the culvert is constructed. For sidewall heights of 5 feet or less, the sidewalls and top slab may be placed in one continuous operation. For sidewalls greater than 5 feet but less than 15 feet in height, allow sidewall concrete to set at least 30 minutes before placing concrete in the top slab. For sidewalls 15 feet or higher, allow sidewall concrete to set at least 12 hours before placing concrete in the top slab.

(6) Precast Elements. Place and consolidate concrete so that shrinkage cracks are not produced in the member.

(c) Placing Methods. Use equipment of sufficient capacity, and ensure that it is designed and operated to prevent mix segregation and mortar loss. Do not use equipment that causes vibrations that could damage the freshly placed concrete. Do not use equipment with aluminum parts that come in contact with the concrete. Remove set or dried mortar from inside surfaces of placing equipment.

Place concrete as near as possible to its final position. Do not place concrete in horizontal layers greater than 2 feet thick. Do not exceed the vibrator capacity to consolidate and merge the new layer with the previous layer. Do not place concrete at a rate that, when corrected for temperature, exceeds the design loading of the forms.

Do not drop unconfined concrete more than 5 feet. Concrete may be confined by using a tube fitted with a hopper head or other approved device that prevents mix segregation and mortar spattering. This does not apply to cast-in-place piling when concrete placement is completed before initial set occurs in the concrete placed first.

In thin sections where there is not sufficient space inside the form to place by chute, place concrete through form windows.

Operate concrete pumps so that a continuous stream of concrete without air pockets is delivered at the tube discharge. Do not use conveyor belt systems longer than 550 feet when measured from end to end of the total belt assembly. Arrange the belt assembly so that each section discharges into a vertical hopper to the next section without mortar adhering to the belt. Use a hopper, chute, and deflectors at the discharge end of the conveyor belt system to cause the concrete to drop vertically.

Arrange the equipment so that no vibrations result that might damage freshly placed concrete.

(d) Consolidation. Provide sufficient hand-held internal concrete vibrators suitable for the conditions of concrete placement. Ensure that the vibrators meet requirements shown in Table 552-5. Provide rubber-coated vibrators when epoxy-coated reinforcement is used.

Table 552-5. - Hand-held vibratory requirements.

Head Diameter (inch)	Frequency (vibrations/min)	Radius of Action (inches)
3/4 to 1 ½	10,000 to 15,000	3 to 5
1 ¼ to 2 ½	9,000 to 13,500	5 to 10
2 to 3 ½	8,000 to 12,000	7 to 19

Provide a sufficient number of vibrators to consolidate each batch as it is placed. Provide a spare vibrator at the site in case of breakdown. Use external form vibrators only when the forms have been designed for external vibration and when internal vibration is not possible.

Consolidate all concrete by mechanical vibration immediately after placement. Manipulate vibrators to thoroughly work the concrete around reinforcement, embedded fixtures, corners, and angles in the forms. Do not cause segregation. Do not consolidate concrete placed underwater. Supplement vibration with spading, as necessary, to provide smooth surfaces and dense concrete along form surfaces, in corners, and at locations impossible to reach with the vibrators.

Vibrate the concrete at the point of deposit and at uniformly spaced points not farther apart than one and one-half times the radius over which the vibration is visibly effective. Insert vibrators so that the affected vibrated areas overlap. Do not use vibrators to move concrete. Insert vibrators vertically, and slowly withdraw them from the concrete. Vibrate long and intensely enough to thoroughly consolidate the concrete, but not to cause segregation. Do not vibrate at any one point long enough to cause localized areas of grout to form. Do not vibrate reinforcement.

(e) Underwater Placement. Underwater placement of concrete is permitted only for seal concrete and drilled shafts. Perform underwater placement only in the presence of the CO. If other than seal concrete is used, increase the minimum cement content by 10 percent. Use tremies, concrete pumps, or other approved methods for placement. Do not place concrete in running water.

(1) Tremies. Use watertight tremies with a diameter of 10 inches or more. Fit the top with a hopper. Use multiple tremies as required. Make tremies capable of being rapidly lowered to retard or stop the flow of concrete and to permit free movement of the discharge end over the entire surface of the cement.

At the start of concrete placement, seal the discharge end and fill the tremie tube with concrete. Keep the tremie tube full of concrete to the bottom during placement, and keep the discharge end completely submerged in the concrete at all times. If water enters the

tube, withdraw the tremie and reseal the discharge end. Maintain continuous concrete flow until the placement is completed.

(2) Concrete Pumps. Use pumps with a device at the end of the discharge tube to seal out water while the tube is first being filled with concrete. When concrete flow is started, keep the end of the discharge tube full of concrete and below the surface of the deposited concrete until placement has been completed.

Place underwater concrete continuously from start to finish in a compact mass. Place each succeeding layer of concrete before the preceding layer has taken initial set. Use more than one tremie or pump as necessary to ensure compliance with this requirement. Keep the concrete surface as horizontal as practicable. Do not disturb after placement. Maintain still water at the point of deposit.

Dewater after test specimens cured under similar conditions indicate that the concrete has sufficient strength to resist the expected loads. Remove all laitance or other unsatisfactory material from the exposed concrete.

(f) Concrete Railings & Parapets. Use smooth, tight-fitting, rigid forms. Neatly miter corners. Place concrete railings and parapets after the centering or Falsework for the supporting span is released. Remove forms without damaging the concrete. Finish all corners to be true, clean-cut, and free from cracks, spalls, or other defects.

Cast precast railing members in mortar-tight forms. Remove precast members from molds as soon as the concrete has sufficient strength to be self-supporting. Protect edges and corners from chipping, cracking, and other damage. Cure in accordance with Subsection 552.17(b). The curing period may be shortened, as approved, by using moist heat and/or Type III cement or water-reducing agents.

552.14 Construction Joints. Provide construction joints at locations as SHOWN ON THE DRAWINGS. Written approval is required for any additional construction joints.

At horizontal construction joints, place gage strips inside the forms along all exposed faces to produce straight joint lines. Clean and saturate construction joints before placing fresh concrete. Keep joints saturated until adjacent fresh concrete is placed. Immediately before placing new concrete, draw forms tight against previously placed concrete. Where accessible, thoroughly coat the existing surface with a very thin coating of cement mortar. Extend reinforcing bars across construction joints.

552.15 Expansion & Contraction Joints. Form expansion and contraction joints as follows:

(a) Open Joints. Form open joints with a wooden strip, metal plate, or other approved material. Remove the joint-forming material without chipping or breaking the corners of the concrete. Do not extend reinforcement across an open joint.

(b) Filled Joints. Cut premolded expansion joint filler to the shape and size of the surface being jointed. Secure the joint filler on one surface of the joint using galvanized nails or

other acceptable means so that it will not be displaced by the concrete. Splice in accordance with the manufacturer's recommendations. After form removal, neatly cut and remove all concrete or mortar that has sealed across the joint. Fill all joint gaps 1/8 inches or wider with hot asphalt or other approved filler. Place all necessary dowels, load transfer devices, and other devices as SHOWN ON THE DRAWINGS or as directed.

(c) Steel Joints. Fabricate plates, angles, or other structural shapes accurately to conform to the concrete surface. Set joint opening to conform to the ambient temperature at the time of concrete placement and as SHOWN ON THE DRAWINGS. Securely fasten the joints to keep them in correct position. Maintain an unobstructed joint opening during concrete placement.

(d) Water Stops. Construct water stops in accordance with Section 712 and as SHOWN ON THE DRAWINGS.

(e) Compression Joint Seals. Use one-piece compression joint seals for transverse joints and the longest practicable length for longitudinal joints. Clean and dry joints and remove spalls and irregularities. Apply a lubricant-adhesive as a covering film to both sides of the seal immediately before installation. Compress the seal and place it in the joint as recommended by the manufacturer. Make sure the seal is in full contact with the joint walls throughout its length.

Remove and discard all seals that are twisted, curled, nicked, or improperly formed. Remove and reinstall joint seals that elongate more than 5 percent of their original length when compressed. Remove all excess lubricant-adhesive before it dries.

(f) Elastomeric Expansion Joint Seal. Install the joint in accordance with the manufacturer's recommendations and the SPECIAL PROJECT SPECIFICATIONS, or as SHOWN ON THE DRAWINGS.

552.16 Finishing Plastic Concrete. Strike off concrete surfaces that are not placed against forms. Float finish the concrete surface. Remove any laitance or thin grout. Carefully tool all nonchamfered edges with an edger. Leave edges of joint filler exposed.

Protect the surface from rain damage.

Finish all concrete surfaces used by traffic to a skid-resistant surface.

(a) Striking Off & Floating. For bridge decks or top slabs of structures serving as finished pavements, use an approved power-driven finishing machine equipped with oscillating screed. If approved, use hand-finishing methods for irregular areas where the use of a machine is impractical.

Limit placement of concrete to that which can be properly finished before the beginning of initial set. Never allow concrete to be placed more than 8 feet ahead of the finishing machine.

Strike off all surfaces using equipment supported by and traveling on screed rails or headers. Do not support rails within the limits of the concrete placement without approval.

Set rails or headers that can be readily adjusted for elevation on nonyielding supports so the finishing equipment operates without interruption over the entire surface being finished. Extend rails beyond both ends of the scheduled concrete placement a sufficient distance to enable the finishing machine to finish the concrete being placed.

Set rails the entire length of steel girder superstructures.

Use rails or headers that are of a type that can be installed so that no springing or deflection will occur under the weight of the finishing equipment.

Adjust rails, headers, and strike-off equipment to the required profile and cross section, allowing for anticipated settlement, camber, and deflection of falsework.

Before beginning delivery and placement of concrete, operate the finishing machine over the entire area to be finished to check for excessive rail deflections, proper deck thickness, and reinforcing steel cover, and to verify proper operation of equipment. Make necessary corrections before concrete placement begins. Obtain approval to begin deck concrete placement.

Schedule delivery and placement of concrete so as to permit all placement and finishing operations to be completed during daylight hours, unless otherwise approved in advance by the CO.

Place concrete bridge decks continuously along the full length of the structure or superstructure unit, unless otherwise SHOWN ON THE DRAWINGS or approved in writing by the CO. Provide sufficient material, equipment, and manpower to complete bridge deck placement at a minimum rate of 20 feet per hour, unless otherwise SHOWN ON THE DRAWINGS.

Should settlement or other unanticipated events occur that would prevent obtaining a bridge deck meeting the requirements of this specification, discontinue placing deck concrete until corrective measures are taken. If satisfactory measures are not taken prior to initial set of the concrete in the affected area, discontinue all placing of concrete and install a bulkhead at a location approved by the CO. Remove all concrete in place beyond the bulkhead.

After placing the concrete, operate the finishing machine over the concrete as needed to obtain the required profile and cross section. Keep a slight roll of excess concrete in front of the cutting edge of the screed at all times. Maintain this excess of concrete to the end of the pour or form and then remove and waste it. Adjust rails or headers as necessary to correct for unanticipated settlement or deflection.

Remove rail supports embedded in the concrete to at least 2 inches below the finished surface, and fill and finish any voids with fresh concrete. Finish the surface with a float, roller, or other approved device as necessary to remove all local irregularities.

Remove all excess water, laitance, or foreign material brought to the surface using a squeegee or straightedge drawn from the center of the slab towards either edge. Do not apply water to the surface of the concrete during finishing operations.

Following the completion of the strike-off, float the roadway slab surface to a smooth, uniform surface by means of floats 10 feet or more in length. Use floats to remove roughness and minor irregularities left by the strike board or finishing machine and to seal the concrete surface. Do not permit excessive working of the concrete surface. Ensure that each transverse pass of the float overlaps the previous pass by a distance equal to at least one-half the length of the float.

Operate hand-operated float boards from transverse finishing bridges. Provide finishing bridges that completely span the roadway area being floated. Provide a sufficient number of finishing bridges to permit operation of the floats without undue delay and to permit inspection of the work. Use at least two transverse finishing bridges when hand-operated float boards are used, unless otherwise approved by the CO.

Provide finishing bridges that are of rigid construction, free of wobble and spring when used by the operators of longitudinal floats, and easily moved.

(b) Straightedging. Check all slab and sidewalk surfaces in the presence of the CO. Check the entire surface parallel to the centerline of the bridge with a 10 foot metal straightedge. Overlap the straightedge at least one-half the length of the previous straightedge placement.

Correct deviations in excess of 1/8 inch from the testing edge of the straightedge. For deck surfaces that are to receive an overlay, correct deviations in excess of ¼ inch.

(c) Texturing. Produce a skid-resistant surface texture on all driving surfaces by grooving. Use grooved, sidewalk, and troweled and brushed finishes, or a combination thereof, for other surfaces as required.

(1) Grooved Finish. Use a float with a single row of fins or an approved machine designed specifically for sawing grooves in concrete pavements. Space fins ½ to ¾ inch on centers. Make the grooves 1/2 to 3/4 inch wide and 1/8 to 3/16 inch deep. Groove perpendicular to the centerline without tearing the concrete surface or loosening surface aggregate.

If grooves are sawn, cut the grooves 3/16 inch wide at a spacing of 9/16 to 1 inch.

On bridge decks, discontinue grooving 12 inches from the curb face and provide a longitudinal troweled finish on the surface of gutters.

(2) Sidewalk Finish. Strike off the surface using a strike board, and then float the surface. Use an edging tool on edges and expansion joints. Broom the surface using a broom with stiff bristles. Broom perpendicular to the centerline from edge to edge, with adjacent strokes slightly overlapped. Produce regular corrugations not more than 1/8 inch in depth without tearing the concrete. While the concrete is plastic, correct porous spots, irregularities, depressions, small pockets, and rough spots. Groove contraction joints at the required interval using an approved grooving tool.

(3) Troweled & Brushed Finish. Use a steel trowel to produce a slick, smooth surface free of bleed water. Brush the surface with a fine brush using parallel strokes.

(4) Exposed Aggregate Finish. Strike off the surface using a strike board and then float the surface. Use an edging tool on all transverse and longitudinal joints that are against forms or existing pavement. Do not edge transverse joints in a continuous pour or longitudinal joints in a continuous dual-lane pour.

As soon as the concrete hardens sufficiently to prevent particles of gravel from being dislodged, broom the surface. Use stiff brushes approved by the CO. Exercise care to prevent marring of the surface and cracking or chipping of slab edges or joints. If approved by the CO, apply a light spray of retardant to the unfinished surface to facilitate this work.

First, broom transversely across the pavement. Pull the loosened semi stiff mortar entirely off the pavement. Remove the mortar from all adjacent pavements. Then broom parallel to the pavement centerline. Continue this operation until a sufficient amount of coarse aggregate is exposed. Other methods of aggregate exposure, such as using a water spray attachment on a special exposed aggregate broom, will be permitted if satisfactory results are demonstrated.

After curing according to Subsection 501.10, wash the surface with brush and water to remove all laitance and cement from the exposed coarse aggregate.

(d) Surface Underneath Bearings. Finish all bearing surfaces to within 3/16 inch of plan elevation. When a masonry plate is to be placed directly on the concrete or on filler material less than 3/16 inch thick, finish the surface with a float to an elevation slightly above plan elevation. After the concrete is set, grind the surface as necessary to provide a full and even bearing.

When a masonry plate is to be set on filler material between 3/16 and ½ inch thick, finish the surface with a steel trowel. Finish or grind the surface so that it does not vary from a straightedge in any direction by more than 1/16 inch.

When a masonry plate is to be set on filler material greater than ½ inch thick or when an elastomeric bearing pad is to be used, finish the surface to a plane surface free of ridges.

When required under a masonry plate or elastomeric bearing pad, use mortar in the proportions of 1 part Portland cement and 1-1/2 parts clean sand. Thoroughly mix sand and cement before adding water. Mix only enough mortar for immediate use. Discard

mortar that is more than 45 minutes old. Do not retemper mortar. Cure mortar at least 3 days, and do not apply loads to mortar for at least 48 hours. Do not mix and use mortar during freezing conditions. Ensure that mortar sand conforms to AASHTO M 45. Proprietary products may be used with approval.

(e) Surface Underneath Waterproofing Membrane Deck Seal. Ensure that surfaces that are to be covered with a waterproofing membrane deck seal are not coarse textured, but rather finished to a smooth surface that is free of ridges and other projections.

552.17 Curing Concrete. Begin curing immediately after the free surface water has evaporated and the finishing is complete. If the surface of the concrete begins to dry before the selected cure method can be implemented, keep concrete surface moist using a fog spray without damaging the surface. Unless otherwise approved by the CO, provide fogging equipment for all deck placement operations.

Use fogging equipment capable of applying water to the concrete in the form of a fine mist in sufficient quantity to curb the effects of rapid evaporation of mixing water from the concrete on the deck. Obtain approval by the CO in advance for fogging nozzles and water supply methods. Produce a true mist that will not harm the surface finish of fresh concrete. Apply the mist at the times and in the manner approved by the CO.

Keep surfaces to be rubbed moist after forms are removed. Cure immediately following the first rub.

Cure the top surfaces of bridge decks using the liquid membrane curing compound method, combined with either the water method or the waterproof cover method. Apply liquid membrane curing compound immediately after finishing. Apply a water method or the waterproof cover method within 4 hours after finishing.

Cure all concrete for at least 7 consecutive days. When pozzolan or fly-ash-modified cement is used, extend the required period of controlled moisture, as called for in Subsection 552.12.

(a) Forms-in-Place Method. For formed surfaces, leave the forms in place without loosening. If forms are removed during the curing period to facilitate rubbing, strip forms only from areas able to be rubbed during the same shift. During rubbing, keep the surface of the exposed concrete moist. After the rubbing is complete, continue curing process using the water method or by applying a clear curing compound (Type 1 or Type 1–D) for the remainder of the curing period.

(b) Water Method. Keep the concrete surface continuously wet by ponding, spraying, or covering with material that is kept continuously and thoroughly wet. Covering material may consist of cotton mats, multiple layers of burlap, or other approved material that does not discolor or otherwise damage the concrete. Do not cure concrete underwater if the temperature of the water is less than 35 °F.

Cover the wet concrete surface with a waterproof sheet material that prevents moisture loss from the concrete.

Use widest sheets practical. Lap adjacent sheets at least 6 inches and tightly seal all seams with pressure-sensitive tape, mastic, glue, or other approved methods. Secure all material so that wind will not displace it. Immediately repair sheets that are broken or damaged.

(c) Liquid Membrane Curing Compound Method. Do not use the liquid membrane method on surfaces to receive a rubbed finish. Use on construction joint surfaces is permitted only if the compound is removed from the concrete and the reinforcing steel by sandblasting before placement of concrete against the joint.

Use Type 2 white-pigmented liquid membrane only on the top surfaces of bridge decks or on surfaces not exposed to view in the completed work. Use Type 1 or 1–D clear curing compounds on other surfaces.

Mix membrane-curing solutions containing pigments before use. Continue to agitate during application. Use equipment capable of producing a fine spray. Apply the curing compound at a minimum rate of 1 Gal/150 ft^2 in one or two uniform applications. If the solution is applied in two applications, follow the first application with the second application within 30 minutes and apply at right angles to the first application.

If the membrane is damaged by rain or other means during the curing period, immediately apply a new coat over the damaged areas.

552.18 Finishing Formed Concrete Surfaces. Remove and replace or repair, as approved, all rock pockets or honeycombed concrete.

Provide a Class 1 finish to all formed concrete surfaces, unless another finish is SHOWN ON THE DRAWINGS or called for in the SPECIAL PROJECT SPECIFICATIONS.

Finish sound formed concrete surfaces as shown below.

(a) Class 1—Ordinary Surface Finish. Finish the following surfaces with a Class 1, ordinary surface finish:

(1) Undersurfaces of slab spans, box girders, filled spandrel arch spans, and the roadway deck slab between superstructure girders.

(2) Inside vertical surfaces of exterior superstructure girders and all vertical surfaces of interior girders.

(3) Surfaces to be buried and culvert surfaces above finished ground that are not visible from the traveled way or a walkway.

Begin finishing as soon as the forms are removed. Remove fins and irregular projections from all surfaces that are exposed or will be waterproofed. Remove bulges and offsets with carborundum stones or discs. Remove localized poorly bonded rock pockets or honeycombed concrete and replace with sound concrete or packed mortar in an approved

manner. Cut back at least 1 inch beneath the concrete surface all projecting wire or other devices used to hold forms in place.

Clean and point all form tie cavities, holes, depressions, voids, broken corners and edges, and other defects. Saturate the area with water. Finish the area with mortar that is less than 1 hour old. After the mortar is set, rub it (if required) and continue curing. Match exposed surfaces to surrounding concrete.

Carefully tool and remove free mortar and concrete from construction and expansion joints. Leave joint filler exposed for its full length with clean, true edges.

Rub or grind bearing surfaces on piers and abutments to the specified elevation and slope.

For patching large or deep areas, add coarse aggregate to the patching material and take special precautions to ensure a dense, well-bonded, and properly cured patch. Areas of honeycomb that exceed 2 percent of the surface area of a structural element may be considered sufficient cause for rejection of the structural element.

Cure mortar patches in accordance with Subsection 552.17.

If the final finished surface is not true and uniform, rub it in accordance with Subsection 552.18(b).

(b) Class 2—Rubbed Finish. Finish the following surfaces with a Class 2 rubbed finish:

(1) All surfaces of bridge superstructures except those surfaces designated to receive a Class 1 or other finish.

(2) All surfaces of bridge piers, piles, columns and abutments, and retaining walls above finished ground and to at least 12 inches below finished ground.

(3) All surfaces of open spandrel arch rings, spandrel columns, and abutment towers.

(4) All surfaces of pedestrian under crossings, except floors and surfaces to be covered with earth.

(5) Surfaces above finished ground of culvert headwalls and end walls when visible from the traveled way or walkway.

(6) Inside surfaces of culvert barrels higher than 3 feet that are visible from the traveled way. Finish for a distance inside the barrel at least equal to the height of the culvert.

(7) All surfaces of railings.

Complete a Class 1 finish in accordance with Subsection 552.18(a). Saturate the concrete surface with water. Rub the surface with a medium-coarse carborundum stone using a small amount of mortar on its face. Use mortar composed of cement and fine sand mixed

in the same proportions as the concrete being finished. Continue rubbing until form marks, projections, and irregularities are removed and a uniform surface is obtained. Leave the paste produced by this rubbing in place.

After other work that could affect the surface is completed, rub with a fine carborundum stone and water until the entire surface has a smooth texture and uniform color. After the surface has dried, rub it with burlap to remove loose powder. Leave it free from all unsound patches, paste, powder, and objectionable marks.

(c) Class 3—Tooled Finish. Let the concrete set for at least 14 days or longer if necessary to prevent the aggregate particles from being "picked" out of the surface. Use air tools such as a bush hammer, pick, or crandall. Chip away the surface mortar and break the aggregate particles to expose a grouping of broken aggregate particles in a matrix of mortar.

(d) Class 4—Sandblasted Finish. Let the concrete set for at least 14 days. Protect adjacent surfaces that are not to be sandblasted. Sandblast the surface with hard, sharp sand to produce an even fine-grained surface in which the mortar is cut away, leaving the aggregate exposed.

(e) Class 5—Wire Brushed or Scrubbed Finish. Begin as soon as the forms are removed. Scrub the surface with stiff wire or fiber brushes using a solution of muriatic acid. Mix the solution in the proportion of 1 part acid to 4 parts water. Scrub until the cement film or surface is completely removed and the aggregate particles are exposed. Leave an even pebbled texture with the appearance of fine granite to coarse conglomerate, depending upon the size and grading of aggregate. Wash the entire surface with water containing a small amount of ammonia.

(f) Class 6—Color Finish. Build a sufficient number of 2 by 4 foot concrete color sample panels to obtain a color acceptable to the CO. Protect the approved color sample panel at all times during the work. Color all designated surfaces to match the color of the approved sample.

Complete a Class 1 finish in accordance with Subsection 552.18(a). Do not apply the color finish until all concrete placement for the structure is complete. Remove all dust, foreign matter, form oil, grease, and curing compound with a 5-percent solution of trisodium phosphate, and then rinse the concrete surface with clean water.

Use paper, cloth, or other means to protect surfaces not to be color finished. Apply the finish to a dry concrete surface when the surface temperature is 40 °F or higher and the air temperature in the shade is anticipated to be 40 °F or higher during the 24 hours following application.

Apply the color finish in accordance with the manufacturer's recommendations. Spray, brush, or roll on the first coat of penetrating sealer and color base. Spray, brush, or roll on the finish coat after the first coat has thoroughly dried. Apply finish to provide a uniform, permanent color, free from runs and sags to the surfaces.

Clean concrete areas not intended to be covered by the finish using an approved method.

552.19 Concrete Anchorage Devices. Use chemical, grouted, or cast-in-place concrete anchorage devices for attaching equipment or fixtures to concrete.

Furnish the following for approval:

(a) Concrete anchorage device sample.

(b) Manufacturer's installation instructions.

(c) Material data and certifications.

Fabricate all metal parts of the anchorage devices from stainless steel or from steel protected with a corrosion-resistant metallic coating that does not react chemically with concrete. Supply anchorage devices complete with all hardware.

For chemical or grouted anchors, conduct a system approval test on one anchor at the jobsite, not to be incorporated in the work. Conduct a static load test in accordance with ASTM E 488. Demonstrate that the anchorage device will withstand a sustained direct tension test load not less than the values shown in Table 552-6 for a period of at least 48 hours with movement not to exceed 1/32 inch. Also demonstrate that, when loaded to failure, the anchorage device demonstrates a ductile failure of the anchor steel, not a failure of the chemical, grout, or concrete.

Install concrete anchorage devices as recommended by the device manufacturer and so that the attached equipment or fixtures will bear firmly against the concrete. Torque installed nuts to the values specified in Table 552-7, unless otherwise specified in the manufacturer's instructions. Set bearing anchor bolts in accordance with the requirements specified in Section 564.

Table 552-6. - Sustained load test values.

Anchorage Device Stud Size (inch)	**Tension Test Load (pounds)**
3/4	5,000
5/8	4,100
1/2	3,200
3/8	2,100
1/4	1,000

Table 552-7. - Torque for Anchorage Devices.

Anchorage Device Stud Size (inch)	Torque (foot pounds)
3/4	125
5/8	95
1/2	60
3/8	35
1/4	10

In the presence of the CO, proof load a random sample of at least 10 percent of the anchors to 90 percent of the yield stress of the steel. If any anchor fails, reset the failed anchor and proof torque the reset anchor and 100 percent of all remaining anchors. The proof load may be applied by torquing against load indicator washers, applying direct tension load to the anchor, or some other method approved by the CO. After proof loading, release the load on the anchor and retighten to the load specified in Table 552-7, or in accordance with the manufacturer's instructions.

552.20 Loads on New Concrete Structures. Do not allow vehicles or construction equipment on any span until concrete in the entire superstructure has attained its design compressive strength and has been in place 21 days.

Do not place any loads on finished piers, bents, or abutments until tests on concrete cylinders cast from the same concrete and cured under the same conditions indicate that the concrete has obtained at least 80 percent of the specified minimum 28-day concrete comprehensive strength. This restriction does not apply to placement of upper lifts for substructure elements cast in stages.

For post tensioned concrete structures, do not allow vehicles weighing more than 4,500 pounds on any span until the prestressing steel for that span is tensioned, grouted, and cured. Vehicles weighing less than 4,500 pounds may be permitted on a span, provided the weight of the vehicle was included in the falsework design.

Permit no public traffic on the bridge until approaches, curbs, bridge rail, and object markers are completed and in place.

Erect barricades at each end of the bridge span upon completion of the deck concreting if road approaches allow vehicles to drive directly onto the structure. Locate barricades so as to physically prevent vehicular access to the bridge. Do not remove barricades until the structure is open to public traffic as approved by the CO.

Measurement

552.21 Method. Use the method of measurement that is DESIGNATED IN THE SCHEDULE OF ITEMS.

Measure structural concrete by the cubic yard or lump sum. Measure in accordance with the neat lines of the structure as SHOWN ON THE DRAWINGS, except as altered by the

CO to fit field conditions. Make no deduction for the volume occupied by reinforcing steel, anchors, weep holes, piling, or pipes less than 8 inches in diameter. Do not include the volume of fillet less than 6 inches on a side or the varying thickness haunches between prefabricated girder and bridge decks.

Payment

552.22 Basis. The accepted quantities will be paid for at the contract unit price for each PAY ITEM DESIGNATED IN THE SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item		**Pay Unit**
552(01)	Structural concrete, class _____	Cubic Yard
552(02)	Structural concrete, class _____	Lump Sum
552(03)	Structural concrete, class _____, for _____ *Description*	Cubic Yard
552(04)	Structural concrete, class , for _____ *Description*	Lump Sum

Section 553 - Prestressed Concrete

Description

553.01 Work. Prestress precast or cast-in-place concrete by furnishing, placing, and tensioning prestressing steel. Manufacture, transport, store, and install all precast prestressed members except piling.

Furnish prestressed members complete, including all concrete, prestressing steel, bar reinforcing steel, and incidentals in connection therewith.

Materials

553.02 Requirements. Furnish material that conforms to specifications in the following sections and subsections:

Elastomeric Bearing Pads	717.10
High-Strength Nonshrink Grout	701.02
Low-Strength Grout	701.03
Mortar	701.04
Prestressing Steel	709.03
Reinforcing Steel	554
Sealants, Fillers, Seals, & Sleeves	712.01
Structural Concrete	552
Structural Steel	717.01

Use Class P concrete in prestressed members unless otherwise SHOWN ON THE DRAWINGS. Design the concrete mix in accordance with Subsection 552.03 with a 28-day design compressive strength as SHOWN ON THE DRAWINGS. Do not permit lightweight concrete unless otherwise SHOWN ON THE DRAWINGS.

Construction

553.03 Method Approval. Notify the CO a minimum of 10 days prior to fabrication of any prestressed members.

Inspect all prestressed concrete members by one of the following methods, unless otherwise SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS:

- Use the quality control engineer of a plant certified by the Prestressed Concrete Institute (PCI). Submit a copy of the transmittal letter of the latest PCI inspection with the shop drawings. Furnish a copy of all testing and inspection reports to the CO upon delivery of the members to the jobsite.

- Use an independent licensed professional engineer experienced in prestressed concrete girder inspection to certify that the prestressed members were built in accordance with the drawings and specifications. Furnish, along with the

certification, a copy of all testing and inspection reports to the CO upon delivery of the members to the jobsite.

Ensure that dimensional tolerances for prestressed girders are as given in Division 5, Section 5 of PCI manual 116–77 (“Manual for Quality Control: Precast Prestressed Concrete Products,” Prestressed Concrete Institute, Chicago, Illinois).

Perform prestressing by pretensioning methods. Submit four copies of shop drawings for prestressed members and one copy of reproducible detailed drawings of the method, material, and equipment proposed for approval at least 21 days before starting prestressing.

Show the following:

(a) Method and sequence of stressing.

(b) Complete specifications, details, and test results for the prestressing steel and anchoring devices.

(c) Anchoring stresses.

(d) Arrangement of the prestressing steel in the members to include the strand pattern at midspan and at centerspan of bearing; and the location of total strand center of gravity at midspan, at hold-down points, at quarter points, and at centerline of bearing.

(e) Tendon elongation calculations for jacking procedures to be used, to include the calibration curve for the gauge and jacking system, the stress-strain curve for the prestressed strands, and the pressure gauge readings.

(f) Number, spacing, and method of draping pretensioned strands.

(g) The prestressing bed layout and overall length between grips at fixed and jacking ends, and the type of equipment to be used.

(h) Other substantiating calculations for the prestressing method.

(i) Certification of wire or strand taken in accordance with Subsection 709.03.

(j) Concrete mix design.

Provide the signature and seal of a licensed professional engineer on all shop drawings and calculations prepared for fabrication of prestressed members.

The CO will review mix designs and approve shop drawings prior to fabrication of prestressed members.

553.04 Prestressing Steel. Use prestressing steel that is bright and free of corrosion, dirt, grease, wax, scale, rust, oil, or other foreign material that may prevent bond between the steel and the concrete. Do not use prestressing steel that has sustained physical damage or is pitted.

One approved splice per pretensioning strand is permitted if the splice is between members in the casting bed. Splice so the strands have the same "twist" or "lay."

Do not weld or ground-welding equipment on forms or other steel in the member after the prestressing steel is installed.

Allow a seven-wire strand with one broken wire to remain in the member, provided it is within the following limits:

For members with:

(a) Less than 20 strands, no wire breaks permitted.

(b) 20 to 39 strands, one wire break permitted.

(c) 40 to 59 strands, two wire breaks permitted.

(d) 60 or more strands, three wire breaks permitted.

Remove and replace all strands that exceed the permissible number of wire breaks.

Remove any strand that has one or more than one broken wire. Securely wrap the broken ends of any wire breaks that are permitted to remain in the member with tie wire to prevent raveling.

553.05 Concrete. Construct prestressed concrete in accordance with Section 552. Construct reinforcing steel in accordance with Section 554.

Ensure that threaded inserts develop the full tensile strength of bars or bolts they secure. Unless otherwise SHOWN ON THE DRAWINGS, provide lifting devices of adequate strength to safely lift the girders within 24 inches of the girder ends.

Straighten wires, wire groups, parallel-lay cables, and any other prestressing elements to ensure proper position in the enclosures. Provide suitable horizontal and vertical spacers, if required, to hold the wires in position.

Do not place concrete in the forms until the placement of reinforcing steel, prestressing steel, ducts, bearing plates, and other embedded material is approved. Place and vibrate concrete with care to avoid displacing the embedded material.

Rough cast the top surface of members against which concrete will be cast.

Determine the strength of precast concrete required prior to release of pretensioned strands by tests on cylinders cast and cured under conditions in which the time temperature-relationship of the cylinder will simulate as nearly as possible that obtained during the curing of the structural member. When the forms are heated by steam or hot air, place the cylinder in the lowest heat zone during the curing period. When forms are heated by some other means, provide a recording of the time temperature relationship of the test cylinder for comparison with that of the prestressed unit.

Mold, cure, and test the cylinders in accordance with AASHTO T 126 and T 22 for 28-day test cylinders, and AASHTO T 23 for test cylinders cured with the members. When accelerated curing methods are used, allow the cylinders to cool for at least one-half hour prior to capping, and allow caps of sulfur compound to cure one-half hour before testing.

Table 553-1. - Prestressed members (from the same placements).

Number of Member/Day	Release Test Cylinders Taken[a]	Minimum Cylinders Broken (Release Test)	28-Day Strength Test Cylinders Taken And Broken[a]
1	3	2	3
2	3	1 per beam	4[b]
3	3[c]	1 per beam	6[b]
4	4[c]	1 per beam	8[b]
5	5[c]	1 per beam	10[b]
6	6[c]	1 per beam	12[b]
7	7[c]	1 per beam	14[b]
8	8[c]	1 per beam	16[b]

a. Assumes all concrete is air-entrained or nonair-entrained. If both types of concrete are used in the same member, the number of test cylinders listed shall be taken from the air-entrained concrete, and the same number of test cylinders shall be taken from the nonair-entrained concrete.
b. Two test cylinders taken from each member.
c. One test cylinder taken from each member.

As a minimum, take the numbers of test cylinders shown in Table 553-1. Take more cylinders if the CO judges it necessary.

Cure the girder in a saturated atmosphere of at least 90 percent relative humidity. Cure time may be shortened by heating the outside of impervious forms with radiant heat, convection heat, conducted steam, or hot air.

Apply radiant heat by means of pipes circulating steam, hot oil, hot water, or electric heating elements. Inspect casting beds to ensure uniform heat application. Use a suitable enclosure to contain the heat. Minimize moisture loss by covering all exposed concrete surfaces with plastic sheeting or liquid membrane curing compound in accordance with Subsection 552.17. Sandblast curing compound from all surfaces to which concrete will be bonded.

When using steam, envelop the entire surface with saturated steam. Completely enclose the casting bed with a suitable type of housing, tightly constructed to prevent the escape

of steam and exclude outside air. Use steam at 100 percent relative humidity. Do not apply the steam directly to the concrete.

When using hot air, the CO will approve the method to envelop and maintain the girder in a saturated atmosphere. Never allow dry heat to touch the girder surface.

For all heat curing methods:

(a) Keep all unformed girder surfaces in a saturated atmosphere throughout the curing time.

(b) Embed a thermocouple (linked with a thermometer accurate to ± 5 °F) 6 to 8 inches from the top or bottom of the girder on its centerline and near its midpoint.

(c) Monitor with a recording sensor (accurate to ± 5 °F) arranged and calibrated to continuously record, date, and identify concrete temperature throughout the heating cycle.

(d) Make this temperature record available to the CO.

(e) Heat concrete to no more the 100 °F during the first 2 hours after placing concrete, and then increase no more than 25 °F per hour to a maximum of 175 °F.

(f) After curing is complete, cool concrete no more than 25 °F per hour to 100 °F.

(g) Keep the temperature of the concrete above 60 °F until the girder reaches release strength.

(h) Do not expose the girders to temperatures below freezing until the specified 28-day strength has been achieved.

(i) To prevent cracking of members, detension strands and transfer their stress to the concrete immediately upon attainment of required release strengths and before the members have been allowed to dry and cool. Should this be impractical, keep the members covered and moist, and hold at a minimum temperature of 60 °F until strands are detensioned.

Cure precast pretensioned members until the concrete has attained the required release compressive strength. The average strength of two test cylinders shall be greater than the minimum required strength. Ensure that the individual strength of any one cylinder is not more than 5 percent below the required strength.

Steam-cure curbs and diaphragms cast after the prestress member has been cured for a minimum of 12 hours at 100 °F to 160 °F or moist-cured for a minimum of 3 days in accordance with Subsection 552.17.

Provide a Class 2 rubbed finish to the exterior surface of the exterior girders and the bottom flanges of all girders, as specified in Subsection 552.18(b), unless otherwise SHOWN ON THE DRAWINGS. Provide a Class 1 ordinary surface finish to the rest of the girders, as specified in Subsection 552.18(a).

Finish portions of prestressed members that will serve as bridge decks, as provided in Subsection 552.16(c)(1) or (2), as appropriate, or as SHOWN ON THE DRAWINGS.

With the approval of the CO, repair rock pockets and other minor deficiencies of a nonstructural nature in the girders. Reject any girders that are repaired without the approval of the CO, regardless of the extent of the repair work.

553.06 Tensioning. Stress strands only when an inspector (see Subsection 553.03) is present. Record the pretensioning gauge pressures and measured strand elongations, and provide a copy to the CO.

Use hydraulic jacks to tension prestressing steel. Use a pressure gage or load cell for measuring jacking force.

Calibrate measuring devices at least once every 6 months, or if they appear to be giving erratic results. Calibrate the jack and gage as a unit, with the cylinder extension in the approximate position to be at final jacking force. Keep a certified calibration chart with each gage.

If a pressure gage is used, do not gage loads less than ¼ or more than ¾ of the total graduated capacity of the gage, unless calibration data clearly establishes consistent accuracy over a wider range. Use a pressure gage with an accurate reading dial at least 6 inches in diameter.

Measure the force induced in the prestressing steel using jacking gages, and take elongation measurements of the prestressing steel. If there is a discrepancy of more than 7 percent between the jacking force and the expected elongation, check the entire operation, determine the reasons for the discrepancy, and correct before proceeding. Recalibrate jacking gages if their readings do not agree within 5 percent of each other. If the jacking system is equipped with an automatic release valve that closes when the required prestressing force is reached, strand elongation measurements are only required for the first and last tendon tensioned and for at least 10 percent of the remaining tendons.

If a load cell is used, do not use the lower 10 percent of the manufacturer's rated capacity of the load cell to determine the jacking force.

Do not exceed a temporary tensile stress in prestressing steel of 80 percent of the specified minimum ultimate tensile strength of the prestressing steel. Anchor prestressing steel at an initial stress that will result in the retention of a working stress after all losses of not less than those required.

For pretensioned members, do not allow the initial release stress after seating and before other losses to exceed 70 percent of the specified minimum ultimate tensile strength of

the prestressing steel for stress-relieved strands, and 75 percent for low relaxation strands. For post tensioned members, do not allow the initial release stress after seating to exceed 70 percent of the specified minimum ultimate tensile strength of the prestressing steel.

553.07 Pretensioned Members. Cast pretensioned members to the tolerances shown in Table 553-2.

Cast pretensioned members in commercial prestressing plants that are PCI-Certified Plants in Product Group B—Bridges, category B3 (Prestressed Straight Strand Bridge Members) or category B4 (Prestressed Draped Strand Bridge Members), as applicable to the members to be manufactured.

(a) Prestressing Steel. Protect prestressing steel placed in the stressing bed from contamination and corrosion if the stressing bed will be exposed to weather for more than 36 hours before encasement in concrete.

Free all strands of kinks or twists. Accurately hold prestressing steel in position, and tension in accordance with Subsection 553.06. Do not allow strands to unwind more than one turn. Keep a record of the jacking force and elongation measurements after the strands are tensioned to 20 percent of final jacking force.

Tension prestressing steel to the required stress. Include in elongation computations strand anchorage slippage, splice slippage, horizontal movement of abutments, and prestressing steel temperature changes between the time of tensioning and the time when the concrete takes its initial set.

Maintain the prestress bed forms, strands, and reinforcement bar temperature within 58 °F of the temperature of the concrete to be placed in the forms. Support strands with rollers at points of direction change when strands are tensioned in a draped position. Use free-running rollers with minimal friction. Initially, when strands are tensioned and then pulled into the draped position, tension to no more than the required tension minus the increased tension due to forcing the strand to a draped profile. If the load in a draped strand at the dead end, as determined by elongation measurements, is less than 95 percent of the jack load, tension the strand from both ends of the bed. Make the load, as computed from the sum of elongations produced by jacking at both ends, agree within 5 percent of the jack load.

Within 3 hours before placing concrete, check the tension on all prestressing steel strands. The method and equipment for checking the loss of prestress shall be subject to approval by the CO. If strands are tensioned individually, check each strand for loss of prestress. Retension to the original computed jacking stress all strands that show a loss of prestress in excess of 3 percent. If strands are tensioned in a group, check the entire group for loss of prestress. Release and retension the entire group if the total prestress shows a loss in excess of 3 percent, or if any individual strand appears significantly different from the rest of the strands in the group.

(b) Releasing Steel. Release the prestress load to the concrete after the concrete has attained its required release compressive strength. Do not expose the concrete to

temperatures below freezing for at least 7 days after casting. Cut or release strands such that lateral eccentricity of the prestress force will be minimized. Cut prestress steel off flush with the end of the member unless otherwise SHOWN ON THE DRAWINGS.

Table 553-2. - Prestressed Concrete Member Tolerances.

Description	Tolerance
Precast Girders With Cast-In-Place Deck[a]	
Length	± ¼ inch/25 feet, ± 1 inch max.
Width (overall)	+ 3/8 inch, - 1/4 inch
Depth (overall)	+ ½ inch, - 1/4 inch
Depth (flanges)	- ¼ inch
Width (web)	+ 3/8 inch, - 1/4 inch
Sweep[b]	1/8 inch/10 feet
Variations from end squareness or skew	± 3/16 inch/foot, ± 1 inch max.
Camber variation from design camber	± 1/8 inch/10 feet ± ½ inch, max. ≤ 80-foot length ± 1 inch, max. >80-foot length
Position of strands:	
Individual	± ¼ inch – bundled
Bundled	± ½ inch
Position from design location of deflection points for deflected strands	± 20 inch
Position of plates other than bearing plates	± 1 inch
Position of bearing plates	± 5/8 inch
Tipping and flushness of plates	± ¼ inch
Tipping and flushness of bearing plates	± 1/8 inch
Position of inserts for structural connections	± ½ inch
Position of handling devices:	
Parallel to length	± 6 inch
Transverse to length	± 1 inch
Position of stirrups:	
Longitudinal spacing	± 2 inch
Projection above top	± 3/4 inch
Local smoothness[c]	± ¼ inch in 10 feet, any surface
Precast Girders Used In Multi-Beam Decks[d]	
Length	± ¾ inch.
Width (overall)	± ¼ inch
Depth (overall)	± ¼ inch
Depth (top flange)	± ½ inch
Depth (bottom flange)	+ ½ inch, - 1/8 inch
Width (web)	± 3/8 inch
Sweep[e]	
Up to 40 foot member length	± ¼ inch
40 foot to 60 foot member length	± 3/8 inch
Greater than 60 foot member length	± ½ inch
Variations from end squareness or skew:	± 1/8 inch/foot
Horizontal	± ½ inch max.
Vertical	± ½ inch
Camber variation from design camber	± 1/8 inch/10 feet ± ½ inch, max.
Differential camber between adjacent members of the same design	½ inch/10 feet ¾ inch max.

Table 553-2. - Prestressed Concrete Member Tolerances (cont.).

Description	Tolerance
Position of strands:	
Individual	± ¼ inch
Bundled	± ¼ inch
Position from design location of deflection points for deflected strands	20 inches
Position of plates other than bearing plates	± 1 inch
Tipping and flushness of plates	± ¼ inch
Position of inserts for structural connections	± ½ inch
Position of handling devices:	
Parallel to length	± 6 inch
Transverse to length	± 1 inch
Position of stirrups:	
Longitudinal spacing	± 1 inch
Projection above top	+ ¼ inch – ¾ inch
Tipping of beam seat bearing area	± 1/8 inch
Position of dowel tubes	± 5/8 inch
Position of tie rod tubes:	
Parallel to length	± ½ inch
Vertical	± 3/8 inch
Position of slab void:	
End of void to center of tie hole	± ½ inch
Adjacent to end block	± 1 inch
Local smoothness[f]	± ¼ inch in 10 feet any surface
Post-Tension Members	
Position of post tensioning ducts	± ¼ inch
Position of tendon anchorage bearing plates	± ¼ inch

[a.] AASHTO I Beams and Bulb Tee Girders.
[b.] Variation from straight line parallel to centerline of member.
[c.] Does not apply to top surface left rough to receive a topping or to visually concealed surfaces
[d.] Box beams, slabs, decked bulb tee, and multistem girders.
[e.] Variation from straight line parallel to centerline of member.
[f.] Does not apply to top surface left rough to receive a topping or to visually concealed surfaces

553.08 Storing, Transporting, & Erecting. Do not ship prestressed concrete members until concrete cylinder tests manufactured of the same concrete and cured under the same conditions as the members indicate that the concrete in each member has attained the minimum required design strength and is at least 14 days old.

Store, transport, and erect precast and prestressed girders, slab units, and box units in the upright position with the points of support and directions of the reactions, with respect to the member, approximately the same as when the member is in its final position, unless otherwise shown on approved shop drawings. Prevent cracking or damage during storage, hoisting, and handling of the precast units. Replace units damaged by improper storage or handling.

Store, transfer, and erect precast prestressed concrete piling in accordance with the requirements for precast concrete piling specified in Section 551. Place other precast

prestressed structural members in the structure as SHOWN ON THE DRAWINGS and in accordance with the SPECIAL PROJECT SPECIFICATIONS.

553.09 Erecting & Placement of Multibeam Members. Advise the CO a minimum of 48 hours before prestressed girders for multibeam bridges are to be field welded, and before any field grout or mortar is to be placed.

Adjust, if necessary, multibeam girders by using galvanized steel shims the same length and width as the bearing pad or plate. Allow no more than 3/16-inch vertical difference between top of adjacent beam edges at each end of the span. When an asphalt wearing surface or cast-in-place deck is to be placed on top of the prestressed beams, allow a vertical tolerance of only 9/16 inches. Do not load beams to make them assume the same camber as an adjacent beam.

Perform abrasive blasting on the keyway surfaces of all multibeam prestressed concrete members to provide a new and clean concrete surface that is free of carbonated concrete and other contaminants, and to expose parts of the large aggregate beneath the concrete paste.

Use high-pressure water blasting (3 psi or more) to remove all debris and loosened paste in the keyways immediately prior to placing mortar. Remove all freestanding water and allow keyways to completely surface dry. Test for the presence of carbonated concrete when directed by the CO or called for by the SPECIAL PROJECT SPECIFICATIONS. Repeat abrasive blasting and water washing as needed if tests indicate the presence of carbonated concrete.

Use mortar in keyways between multibeam members and to patch defects, blockouts, or other areas on the concrete roadway portion of the structure 1 inch or more in depth and over 1 inch in width. Patch smaller areas on the concrete roadway with grout.

Maintain air and concrete keyway temperatures between 45 °F and 86 °F before placing mortar. Maintain the temperature within these limits until mortar placement and application of curing method is completed.

Use grout on all anchor bolts and dowels to make all repairs.

Require air and concrete temperatures for grout placement to be the same as required for mortar. Thoroughly saturate the areas to be grouted with water and remove all free standing water just prior to grout placement.

Strike off exposed grout surfaces flush with the same surface texture finish as the surrounding concrete as soon as the grout has set sufficiently. Cure the exposed surface as specified in Subsection 552.17. When artificial means are used to control the curing temperature of the mortar or grout, as during hot or cold weather, the CO will approve the method in advance. Use combustion heaters only if fully vented outside their enclosure. Store all dry mortar materials and mixing and placing equipment such that their temperature is above freezing. Warm mixing water to provide mortar or grout at desired temperature, but ensure that it is at 86 °F or less when mixed with the dry materials. Use

ice as part of the mixing water provided it is completely melted prior to the introduction of the water to the dry materials.

Ensure that patching mortar and grout are the same color as the parent concrete.

Ensure that all field welding meets the requirements specified in Section 555. When welding or burning on precast members, attach the ground lead directly to the base metal; reject any precast prestressed member used as a conductor for the ground, and replace the member without compensation.

553.10 Painting Steel. Use a wire brush or abrasive blast to remove all dirt and residue not firmly bonded to the metal or concrete surfaces. Clean and paint the exposed ends of the prestress steel, posttension anchor head assemblies, and a 1 inch strip of adjoining concrete.

Mix zinc-rich paint conforming to Federal Specifications and Standards (FSS) TT–P–641. Work the paint into all voids in the prestressing tendons. Apply one thick coat to surfaces that will be covered with concrete. Apply two coats to surfaces not covered with concrete.

Measurement

553.11 Method. Use the method of measurement that is DESIGNATED IN THE SCHEDULE OF ITEMS.

Measure precast prestressed structural concrete members by the each or by the linear foot.

Measure prestressed piling under Section 551.

Payment

553.12 Basis. The accepted quantities will be paid for at the contract unit price for each PAY ITEM DESIGNATED IN THE SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item		**Pay Unit**
553(01)	Precast prestressed concrete structural members, _____ *Description*	Each
553(02)	Precast prestressed concrete structural members, _____ *Description*	Linear Foot

Section 553A - Precast Concrete Structures

Description

553A.01 Work. Construct precast concrete members. In addition, manufacture, test materials for, transport, store, and install all precast concrete portions except piling, and perform all necessary grouting, welding, or other connections. Furnish precast concrete members complete and in place, including all concrete reinforcing steel and incidentals connected therewith.

Materials

553A.02 Requirements. Provide materials that meet the requirements specified in the following subsections:

Elastomeric Bearing Pads	717.10
High-Strength Nonshrink Grout	701.02
Low-Strength Grout	701.03
Mortar	701.04
Reinforcing Steel	709.01
Sealants, Fillers, Seals, & Sleeves	712.01
Structural Concrete	552.02
Structural Steel	717.01

Provide precast concrete members of the size, shape, strength, air content, and finish that are SHOWN ON THE DRAWINGS.

Perform all sampling, testing, and inspection necessary to ensure quality control of the component materials and the concrete. Sample and test for quality control and acceptance testing in accordance with the AASHTO or ASTM test methods prescribed in Section 552.

Maintain adequate records of all inspections and tests. Keep records that indicate the nature and number of observations made, the number and type of deficiencies found, the quantities approved and rejected, and the nature of any corrective action taken.

Sample and test every batch (100 percent sampling and testing) for air content and slump at the start of concrete production. Random sampling and testing for air content and slump at the rate of one for every five successive batches may be substituted for 100 percent sampling and testing if the test results for three successive batches are within the specification limitations for air content or slump; but reinstate 100 percent sampling and testing if a test result for any random sample is outside the specification limitations for either air content or slump.

Make compression tests to determine the minimum strength requirements on cylinders. Make a minimum of four cylinders from each day’s production, and cure them in the same manner as the precast units. Use testing methods in accordance with AASHTO T 22.

Furnish, or have the supplier furnish, a Certificate of Compliance to the CO certifying that the above materials comply with the applicable specifications. In addition, furnish to the CO a copy of all test results performed by the Contractor or supplier that are necessary to ensure compliance.

Construction

553A.03 Performance. Construct precast concrete structural members in accordance with the following sections and subsections, as applicable:

Erecting and Placement of Multibeam Members.....553.09
Reinforcing Steel 554
Storing, Transporting, & Erecting 553.08
Structural Concrete 552

Submit four sets of shop drawings to the CO for approval, including the concrete mix design for each class of concrete proposed for use, a minimum of 21 days before fabrication of the precast member(s).

553A.04 Casting Yard. The precasting of concrete structural members may be done at a casting yard location selected by the Contractor.

553A.05 Handling, Transporting, & Erecting. Provide additional reinforcement, as needed, to meet the requirements of handling, transporting, and erecting precast members.

Measurement

553A.06 Method. Use the method of measurement that is DESIGNATED IN THE SCHEDULE OF ITEMS.

Each member will include the concrete, reinforcement steel, anchorages, plates, nuts, and other material contained within or attached to the unit.

Payment

553A.07 Basis. The accepted quantities will be paid for at the contract unit price for each PAY ITEM DESIGNATED IN THE SCHEDULE OF ITEMS.

Payment will be made under

Pay Item	**Pay Unit**
553A(01) Precast concrete member, _____ *Description*	.....Each
553A(02) Precast concrete structure, _____ *Description*	.....Lump Sum

Section 554 - Reinforcing Steel

Description

554.01 Work. Furnish and place reinforcing steel.

Materials

554.02 Requirements. Furnish material that conforms to specifications in the following subsections:

Reinforcing Steel 709.01

Construction

554.03 Order Lists. When SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS, submit all order lists and bending diagrams to the CO for approval. Approval does not relieve the Contractor of responsibility for the accuracy of the lists and diagrams. Do not order material until the lists and diagrams are approved.

Do not fabricate vertical reinforcement in columns, walls, piers, and shafts until footing elevations are established in the field, unless otherwise SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS.

554.04 Identification. Ship bar reinforcement in standard bundles tagged and marked in accordance with the "Manual of Standard Practice" by the Concrete Reinforcing Steel Institute (CRSI).

554.05 Bending. Fabricate reinforcing bars in accordance with ACI SP 66. Cold bend all reinforcing bars that require bending. Limit the overall height or drop bending tolerance of deck truss bars to 0 inch or minus ¼ inch. Do not bend bars partially embedded in concrete except as SHOWN ON THE DRAWINGS or otherwise permitted.

When the dimensions of hooks or the diameter of bends is not SHOWN ON THE DRAWINGS, provide standard hooks conforming to ACI SP 66.

554.06 Protection of Material. Store reinforcing steel above the ground on platforms, skids, or other supports. Protect from physical damage, rust, and other surface deterioration.

Use reinforcing steel only when the surface is clean and the minimum dimensions, cross-sectional area, and tensile properties conform to the physical requirements for the size and grade of steel specified.

Do not use reinforcing steel that is cracked, laminated, or covered with dirt, rust, loose scale, paint, grease, oil, or other deleterious material.

554.07 Epoxy-Coated Reinforcing Steel. Support coated bars on padded contact areas. Pad all bundled bands. Lift with a strong back, multiple supports, or a platform bridge. Prevent bar-to-bar abrasion. Do not drop or drag bundles.

Before placement, inspect coated bars for damage to the coating. Patch all defects in the coating that are discernible to the unaided eye with a prequalified patching/repair material, in accordance with AASHTO M 284. Clean areas to be patched by removing all surface contaminants and damaged coating. Roughen the area to be patched before applying the patching material. Where rust is present, remove the rust by blast cleaning or power-tool cleaning immediately before applying the patching material.

Promptly treat the bar in accordance with the resin manufacturer's recommendations and before detrimental oxidation occurs. Overlap the patching material onto the original coating for 2 inches or as recommended by the manufacturer. Provide a minimum 8-mil dry film thickness on the patched areas.

Take necessary steps to minimize damage to the epoxy coating of installed bars. Clean and patch any damage to the coating noted after installation, as described above.

Field repairs will not be allowed on bars that have severely damaged coatings. Replace bars with severely damaged coatings. A severely damaged coating is defined as a coating with a total damaged area in any 1 foot length of bar that exceeds 5 percent of the surface area of that portion of the bar. Coat mechanical splices after splice installation in accordance with AASHTO M 284M for patching damaged epoxy coatings.

554.08 Placing & Fastening. Support the bars on precast concrete blocks or metal supports in accordance with the CRSI "Manual of Standard Practice of the Concrete Reinforcing Steel Institute." Attach concrete block supports to the supported bar with 1/16 inch wire cast in the center of each block. Use Class 1 (plastic-protected) or Class 2, Type B (stainless-steel-protected) metal supports in contact with exposed concrete surfaces. Use stainless steel conforming to ASTM A 493, Type 430. Coat chairs, tie wires, and other devices used to support, position, or fasten epoxycoated reinforcement with a dielectric material. Do not use plastic, wood, aluminum, brick, or rock supports.

Space slab bar supports no more than 4 feet apart transversely or longitudinally. Do not use bar supports either directly or indirectly to support runways for concrete buggies or other similar construction loads.

Space parallel bars within 1 1/2 inches of the required location. Do not accumulate spacing variations. Ensure that the average of any two adjacent spaces does not exceed the required spacing.

Provide 2 inches clear cover for all reinforcement except as otherwise SHOWN ON THE DRAWINGS.

Place reinforcing steel in deck slabs within 1/4 inch of the vertical plan location. Tie bridge deck reinforcing bars together at all intersections, except where spacing is less than 12 inches in both directions, in which case alternate intersections may be tied. Check

the clear cover over deck-reinforcing steel using a template before placing deck concrete. Replace damaged supports.

Tie every reinforcing-steel intersection at the outside edges of decks, in top mats of footings, and in all precast and/or prestressed concrete units.

Tie bundle bars together at intervals not exceeding 6 feet. Do not bundle bars unless the location and splice details are specified.

Do not place concrete in any member until the placement of the reinforcement is approved by the CO. Concrete placed without approval may be rejected, and the Contractor may be required to remove it without compensation.

554.09 Splices. Splicing, except as SHOWN ON THE DRAWINGS, is not permitted without approval. Provide lap lengths as SHOWN ON THE DRAWINGS or in accordance with the latest edition of "Standard Specifications for Highway Bridges," published by AASHTO.

Splice reinforcing bars only where SHOWN ON THE DRAWINGS. Do not place slab bar mechanical splices adjacent to each other.

Make lapped splices by placing the reinforcing bars in contact and wiring them together with at least three ties to maintain the alignment and position of the bars.

If welding of reinforcing steel is permitted, ensure that the welds conform to AWS D 1.4. Do not weld reinforcing steel if the chemical composition of the steel exceeds the percentages shown in Table 554-1.

Use welders that are currently certified. When required, test each weld using magnetic particle, radiography, or other nondestructive inspection techniques.

Table 554-1. - Reinforcing steel components.

Chemical Composition	Percent
Carbon	0.30
Manganese	1.50
Carbon equivalent	0.55

Do not tack-weld reinforcing steel.

Mechanical couplers may be used in lieu of welding, if approved. Use couplers with a strength that is at least 125 percent of the required yield strength of the reinforcing steel.

If welded wire fabric is shipped in rolls, straighten into flat sheets before placing. Splice sheets of mesh or bar mat reinforcement by overlapping not less than 1 mesh width plus 2 inches. Securely fasten at the ends and edges.

Measurement

554.10 Method. Use the method of measurement that is DESIGNATED IN THE SCHEDULE OF ITEMS.

Measure reinforcing steel by the pound or by the lump sum, excluding laps added for the Contractor's convenience.

Payment

554.11 Basis. The accepted quantities will be paid for at the contract unit price for each PAY ITEM DESIGNATED IN THE SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item		Pay Unit
554(01)	Reinforcing steel	Pound
554(02)	Epoxy-coated reinforcing steel	Pound
554(03)	Reinforcing steel	Lump Sum

Section 555 - Steel Structures

Description

555.01 Work. Construct steel structures and the steel structure portions of composite structures. Furnish, fabricate, and erect structural steels, and perform incidental metal construction.

Materials

555.02 Requirements. Furnish material that conforms to specifications in the following sections and subsections:

Bearing Devices	564
Bolts & Nuts	717.01(d)
Castings	717.04
Elastomeric Compression Joint Seals	717.16
Falsework	562
Galvanized Coatings	717.07
High-Strength Bolts, Nuts, & Washers	717.01(e)
Painting	563
Pins & Rollers	717.03
Sheet Lead	717.08
Steel Forgings	717.02
Steel Grid Floors	717.09
Steel Pipe	717.06
Structural Steel	717.01
Welded Stud Shear Connectors	717.05

Construction

555.03 General. Fabricate the structural steel in a fabricating plant that is certified under the American Institute of Steel Construction (AISC) Quality Certification Program. Fabricate "fracture-critical" elements in accordance with the AASHTO "Guide Specifications for Fracture Critical Non-Redundant Steel Bridge Members."

Perform welding and weld qualification tests in accordance with the provisions of American National Standards Institute (ANSI)/AASHTO/AWS Bridge Welding Code D1.5.

555.04 Notice of Beginning of Work. Give written notice 30 days before beginning work at the shop. Do not manufacture any material or perform any work in the shop before notification.

555.05 Inspection. Structural steel may be inspected at the fabrication site.

Ultrasonically inspect all girder flanges before fabrication, in accordance with ASTM A 578, except as follows:

(a) Inspect after the flanges are stripped from the master plate.

(b) Section 6 and 7 acceptance standards do not apply. Use supplementary requirement S2.1 for acceptance standards.

(c) Flanges may be inspected in the plant or warehouse where the flanges are stripped.

Furnish a copy of all mill orders and certified mill test reports. Show on the mill test reports the chemical analyses and physical test results for each heat of steel used in the work.

If approved, furnish production certificates in lieu of mill test reports for material that normally is not supplied with mill test reports and for items such as fills, minor gusset plates, and similar material when quantities are small and the material is taken from stock.

Include in the certified mill test reports for steels with specified impact values, in addition to other test results, the results of Charpy V-notch impact tests. When finegrain practice is specified, confirm on the test report that the material was so produced. Furnish copies of mill orders at the time orders are placed with the manufacturer. Furnish certified mill test reports and production certificates before the start of fabrication using material covered by these reports. Furnish, from the manufacturer, a Certificate of Compliance in accordance with Subsection 106.03.

555.06 Drawings (Shop Drawings, Erection Drawings, & Transportation Drawings). Prepare and submit drawings at the times indicated herein. Approval of the drawings covers the requirements for strength and detail only. No responsibility is assumed for errors in dimensions.

(a) Shop Drawings. Submit four copies of shop drawings at least 21 days in advance of the start of fabrication to allow time for review without delaying the work. Show full detailed dimensions and sizes of component parts of the structure and details of all miscellaneous parts (such as pins, nuts, bolts, drains, weld symbols, and so forth) on shop drawings for steel structures.

Where specific orientation of plates is required, show the direction of rolling of plates. Cut flanges and webs of plate girders from plates so the long dimension of the girder parallels the rolling direction.

Show the sequence of shop and field assembly and erection, and all welding sequences and procedures.

Identify on the shop drawings the type and grade of each piece.

Show on the shop drawings assembly marks that are cross-referenced to the original pieces of mill steel and their certified mill test reports.

The location of all shop-welded splices shown on the shop drawings is subject to approval. Locate all shop-welded splices to avoid points of maximum tensile or fatigue stress. Locate splices in webs at least 12 inches from shop splices, butt joints in flanges, or stiffeners. Additional nondestructive tests may be required on shopwelded splices.

(b) Erection Drawings. Submit drawings fully illustrating the proposed method of erection a minimum of 21 days before field assembly and erection. Show details of all falsework bents, bracing, guys, dead-men, lifting devices, and attachments to the bridge members. Show the sequence of erection, location of cranes and barges, crane capacities, location of lifting points, and weights of bridge members. Show complete details for all anticipated phases and conditions of erection. Calculations may be required to demonstrate that allowable stresses are not exceeded and that member capacities and final geometry will be correct. See Subsection 562.03 for additional requirements.

(c) Camber Diagram. Along with the shop drawings, furnish a camber diagram complete with substantiating calculations that show the camber at each panel point of trusses or arch ribs and at the location of field splices and fractions of span length (one-quarter points minimum) of continuous beams and girders or rigid frames. On the camber diagram, show calculated cambers to be used in preassembly of the structure, as required in Subsection 555.15.

(d) Transportation Drawings. If required, furnish transportation drawings for approval a minimum of 10 days prior to shipment.

Show all support points, tie-downs, temporary stiffening trusses or beams, and any other details needed to support and brace the member. Provide calculation sheets showing the dead load plus impact stresses induced by the loading and transportation procedure. Use impact stresses of at least 200 percent of the dead load stress. Use a total load, including impact, of not less than 300 percent of the dead load.

Ship and store all members, both straight and curved, with their webs vertical.

555.07 Storage of Material. Store structural material above the ground on platforms, skids, or other supports. Keep material free from dirt, grease, and other foreign matter, and provide appropriate protection from corrosion.

555.08 Fabrication. Provide a workmanship and finish in accordance with the best general practice in modern bridge shops. Finish neatly all portions of the work exposed to view. Perform shearing, flame cutting, and chipping carefully and accurately.

Rolled material must be straight before being laid off or worked. If straightening is necessary, use methods that will not injure the metal. Sharp kinks and bends will be cause for rejection of the material.

Heat curving of steel girders is not allowed.

(a) Identification of Steels. Use a system of assembly-marking of individual pieces and cutting instructions to the shop (generally by cross-referencing of the assembly marks shown on the shop drawings with the corresponding item covered on the mill purchase order) that maintains the identity of the original piece.

Material may be furnished from stock that can be identified by heat number and mill test report.

During fabrication, up to the point of assembling members, show clearly and legibly the specification of each piece of steel by writing the material specification on the piece or using the identification color code shown in Table 555-1.

Table 555-1. - Identification color codes.

Grade	Color
50	Green and yellow
50W	Blue and yellow
70W	Blue and orange
100	Red
100W	Red and orange

For other steels not shown in Table 555-1 or included in AASHTO M 160, provide information on the color code used.

Mark for grade by steel-die stamping, or by firmly attaching a substantial tag, pieces of steel that, before assembling into members, will be subject to fabrication operations (such as blast cleaning, galvanizing, heating for forming, or painting) that might obliterate paint color code marking. Where the steel-stamping method is used, place the impressions on the thicker tension-joint member in transition joints.

The maximum allowed depth of the impression is 0.01 inch. Use a tool that will make character sizes with corresponding face radii as shown in Table 555-2. Avoid impressions near edges of tensile-stressed plate members.

Table 555-2. - Size of steel die stamp markings.

Character Size (inch)	Minimum Face Radii (inch)
1/8	0.007
3/16	0.003
1/4	0.010

Use low-stress-type steel die stamps. Do not use die stamps on fracture-critical members.

If requested, furnish an affidavit certifying that the identification of steel has been maintained throughout the fabrication operation.

(b) Plates. Conform to the following:

(1) Direction of Rolling. Unless otherwise SHOWN ON THE DRAWINGS, cut and fabricate steel plates for main members and splice plates for flanges and main tension members, not secondary members, so that the primary direction of rolling is parallel to the direction of the principal tensile and/or compressive stresses.

(2) Plate Cut Edges. Conform to the following:

(a) Edge Planing. Remove sheared edges on plates thicker than 9/16 inches to a depth of 3/16 inch beyond the original sheared edge, or beyond any re-entrant cut produced by shearing. Fillet re-entrant cuts before cutting.

(1) Oxygen Cutting. Oxygen cut structural steel in accordance with ANSI/ AASHTO/AWS Bridge Welding Code D1.5.

(2) Visual Inspection & Repair of Plate Cut Edges. Visually inspect and repair plate cut edges. Ensure that cut edges conform to ANSI/AASHTO/AWS Bridge Welding Code D1.5.

(b) Flange Plates. Furnish flange plates with oxygen-cut edges that have the corners chamfered at least 1/16 inch by grinding, or furnish universal mill plates unless oxygen-cut edges are required.

(c) Web Plates. Oxygen cut to the prescribed camber web plates of built-up beams and girders, box girders, and box arches. Cut sufficient extra camber into the webs to provide for all camber losses due to welding, cutting, and so forth.

(d) Truss Members. Use oxygen cutting to prepare all longitudinal edges of all plates in welded sections of truss web and chord members. Chamfer at least 1/16 inch by grinding the edges of the corners of plates not joined by welding.

(e) Stiffeners & Connection Plates. Stiffeners and connection plates welded transverse to girder webs and flanges may be furnished with sheared edges, provided that the plate thickness does not exceed 3/4 inches. Universal mill plate may be used, provided that its thickness does not exceed 1 inch. Furnish other stiffeners and connection plates with oxygen-cut edges.

(f) Lateral Gusset Plates. Oxygen cut, parallel to lines of stress, gusset plates and other connections that are welded parallel to lines of stress in tension members where the plate thickness exceeds 3/8 inch. Bolted lateral gusset plates may be furnished with sheared edges, provided the thickness is less than or equal to 3/4 inch.

(g) Splice Plates & Gusset Plates. Furnish girder and stringer splice plates and truss gusset plates with oxygen-cut edges.

(h) Bent Plates. Furnish unwelded, load-carrying, rolled-steel plates to be bent as shown in Table 555-3.

Table 555-3. - Minimum bending radii.[a]

Plate Thickness (inches)	Bending Radius[b]
$t \leq ½$	2(t)
$½ < t \leq 1.0$	2.5(t)
$1.0 < t \leq 1.5$	3(t)
$1.5 < t \leq 2.5$	3.5(t)
$2.5 < t \leq 4$	4(t)

[a] t = plate thickness.
[b] For all grades of structural steel.

Take material from the stock plates such that the bend line will be at right angles to the direction of rolling, except that cold-bent ribs for orthotropic deck bridges may be bent with bend lines in the direction of rolling.

Before bending, round the corners of the plates to a radius of 1/16 inches throughout the portion of the plate where the bending occurs.

(1) Cold Bending. Cold bend so that no cracking of the plate occurs. Use the minimum bend radii shown in Table 555-3 measured to the concave face of the metal.

Allow for springback of Grade 100 and Grade 100W steels equal to about 3 times that for Grade 36 steel. Use a lower die span of at least 16 times the plate thickness for break press forming.

(2) Hot Bending. If a radius shorter than the minimum specified for cold bending is essential, hot bend the plates at a temperature not greater than 1,200 °F, except for grades 100 and 100W. When Grade 100 and Grade 100W steel plates are heated to temperatures greater than 1,130 °F, requench and temper in accordance with the producing mill's standard practice.

(c) Fit of Stiffeners. Fabricate (mill, grind, or weld as SHOWN ON THE DRAWINGS or as specified) end-bearing stiffeners for girders and stiffeners intended as supports for concentrated loads to provide full bearing on the flanges to which they transmit load or from which they receive load. Fabricate intermediate stiffeners not intended to support concentrated loads to provide a tight fit against the compression flange.

(d) Abutting Joints. Mill or saw-cut abutting joints in compression members of trusses and columns to give a square joint and uniform bearing. The maximum allowed opening at other joints, not required to be faced, is 3/8 inches.

(e) Facing of Bearing Surfaces. Finish bearing and base plates and other bearing surfaces that will come in contact with each other or with concrete to the ANSI surface roughness defined in ANSI B46.1, *"Surface Roughness, Waviness and Lay, Part I*," as shown in Table 555-4.

Table 555-4. - ANSI surface roughness values.	
Bearing Surface	**Surface Roughness Value (μ inch)**
Steel slabs	2,000
Heavy plates in contact in shoes to be welded	1,000
Milled ends of compression members, milled or ground ends of stiffeners and fillers	500
Bridge rollers and rockers	250
Pins and pin holes	125
Sliding bearings	125

Machine sliding bearings that have a surface roughness greater than ANSI 60, so the lay of the cut is parallel to the direction of movement.

Fabricate parts in bearing to provide a uniform, even contact with the adjacent bearing surface when assembled. Limit the maximum gap between bearing surfaces to 1/32 inch. Base and sole plates that are plane and true and have a surface roughness not exceeding the above-tabulated values need not be machined, except machine sliding surfaces of base plates.

Do not machine surfaces of fabricated members until all fabrication on that particular assembly or subassembly is complete. Machine metal components that are to be heat-treated after heat treatment.

(f) Straightening Material. If approved, straighten plates, angles, other shapes, and built-up members by methods that will not produce fracture or other damage to the metal. Straighten distorted members by mechanical means or, if approved, by carefully planned procedures and supervised application of a limited amount of localized heat. Use rigidly controlled procedures and do not exceed the temperatures specified in Table 555-5 when heat straightening grades 70W, 100, and 100W steel members.

In all other steels, do not exceed 1,200 °F in the heated area. Control the application by temperature-indicating crayons, liquids, or bimetal thermometers.

Keep parts to be heat-straightened substantially free of external forces and stress, except stresses resulting from mechanical means used in conjunction with the application of heat.

Table 555-5. - Heat-straightening temperatures.	
Material To Be Straightened	**Maximum Temperature**
Grade 70W > 6 inches from weld	1,075 ^{o}F
Grade 70W < 6 inches from weld	900 ^{o}F
Grade 100 or 100W > 6 inches from weld	1,125 ^{o}F
Grade 100 or 100W < 6 inches from weld	950 ^{o}F

Evidence of fracture following straightening of a bend or buckle will be cause for rejection of the damaged piece.

555.09 Annealing & Stress Relieving. Machine, finish bore, and straighten annealed or normalized structural members subsequent to heat treatment. Normalize and anneal (full annealing) in accordance with ASTM A 919. Maintain uniform temperatures throughout the furnace during the heating and cooling so that the temperature at any two points on the member does not differ by more than 140 °F at any one time.

Do not anneal or normalize members of grades 100/100W or 70W steels. Stress relieve these grades only with approval.

Record each furnace charge, identify the pieces in the charge, and show the temperatures and schedule actually used. Provide proper instruments, including recording pyrometers, for determining at any time the temperatures of members in the furnace. Make records of the treatment operation available for approval. The maximum allowed holding temperature for stress relieving grades 100/100W and 70W steels is 1,125 °F and 1,075 °F, respectively.

Stress relieve members (such as bridge shoes, pedestals, or other parts that are built up by welding sections of plate together) in accordance with subsection 4.4 of ANSI/ AASHTO/AWS Bridge Welding Code D1.5.

555.10 Bolt Holes. Punch or drill all bolt holes. Material forming the parts of a member that is composed of not more than five thicknesses of metal may be punched 1/16 inch larger than the nominal diameter of the bolts where the thickness of the material is not greater than 3/4 inch for structural steel, 9/16 inch for high-strength steel, or 9/16 inch for quenched and tempered alloy steel, unless subpunching and reaming is required under Subsection 555.10(h), Preparation of Field Connections.

Where there are more than five thicknesses or where any of the main material is thicker than 3/4 inch for structural steel, 9/16 inch for high-strength steel, or 9/16 inch for quenched and tempered alloy steel, either subdrill and ream or drill all holes full size.

If required, either subpunch or subdrill (subdrill if thickness limitation governs) 3/16 inch smaller and, after assembling, ream 1/16 inch larger or drill full size to 1/16 inch larger than the nominal diameter of the bolts.

(a) Punched Holes. Use a die diameter that is not more than 1/16 inch larger than the punch diameter. Ream holes that require enlarging to admit bolts. Cut the holes clean without leaving torn or ragged edges.

(b) Reamed or Drilled Holes. Ream or drill holes so they are cylindrical and perpendicular to the member. Where practical, direct reamers by mechanical means. Remove burrs on the outside surfaces. Ream and drill with twist drills, twist reamers, or roto-broach cutters. Assemble and securely hold together connecting parts that are being reamed or drilled and match-mark before disassembling.

(c) Accuracy of Holes. Holes not more than 1/32 inch larger in diameter than the true decimal equivalent of the nominal diameter of the drill or reamer are acceptable. The slightly conical hole resulting from punching operations is acceptable. Ensure that the width of slotted holes produced by flame cutting or a combination of drilling or punching and flame cutting is no more than 1/32 inch greater than the nominal width. Grind flame-cut surfaces smooth.

(d) Accuracy of Hole Group Before Reaming. Accurately punch full-size, subpunched, or subdrilled holes so that after assembling (before any reaming is done) a cylindrical pin 1/8 inch smaller in diameter than the nominal size of the punched hole may be entered perpendicular to the face of the member, without drifting, in at least 75 percent of the contiguous holes in the same plane. Punched pieces not meeting this requirement will be rejected. Holes through which a pin 3/16-inch smaller in diameter than the nominal size of the punched hole cannot be inserted will be rejected.

(e) Accuracy of Hole Group After Reaming. After reaming, the maximum allowed offset of 85 percent of any contiguous group of holes through adjacent thicknesses of metal is 1/32 inch.

Use steel templates with hardened-steel bushings in holes accurately dimensioned from the centerlines of the connection, as inscribed on the template. Use connection centerlines when locating templates from the milled or scribed ends of members.

(f) Numerically Controlled (N/C) Drilled Field Connections. In lieu of drilling undersized holes and reaming while assembled, or drilling holes full-size while assembled, drilling or punching bolt holes full-size is allowed in unassembled pieces and/or connections, including templates for use with matching undersized and reamed holes by means of suitable N/C drilling or punching equipment.

(***g) Holes for Ribbed Bolts, Turned Bolts, or Other Approved Bearing-Type Bolts.*** Provide finished holes with a driving fit.

(h) Preparation of Field Connections. Subpunch or subdrill and ream while assembled, or drill full-size to a steel template, holes in all field connections and field splices of main members of trusses, arches, continuous beam spans, bents, towers (each face), plate girders, and rigid frames.

Holes for field splices of rolled beam stringers continuous over floor beams or cross frames may be drilled full-size unassembled to a steel template. Holes for floor beams or cross frames may be drilled full-size unassembled to a steel template. Subpunch and ream while assembled, or drill full-size to a steel template, all holes for floor beam and stringer field end connections.

When reaming or drilling full-size field connection holes through a steel template, carefully locate and position the template and firmly bolt in place before drilling. Use exact duplicates of templates used for reaming matching members, or the opposite faces of a single member. Accurately locate templates used for connections on like parts or members so that the parts or members are duplicates and require no match-marking.

For any connection, in lieu of subpunching and reaming or subdrilling and reaming, holes drilled full-size through all thicknesses or material assembled in proper position may be used.

555.11 Pins & Rollers. Accurately fabricate pins and rollers that are straight, smooth, and free from flaws. Forge and anneal pins and rollers more than 9 inches in diameter. Pins and rollers 9 inches or less in diameter may be either forged and annealed or cold-finished carbon-steel shafting.

In pins larger than 9 inches in diameter, bore a hole not less than 2 inches in diameter full length along the pin axis after the forging has been allowed to cool to a temperature below the critical range (under suitable conditions to prevent damage by too-rapid cooling and before being annealed).

(a) Boring Pin Holes. Bore pin holes true to the specified diameter, smooth and straight, at right angles with the axis of the member and parallel with each other. Produce the final surface using a finishing cut.

Produce a pin hole diameter that does not exceed that of the pin by more than 1/64 inch for pins 5 inch or less in diameter, or by 1/32 inch for larger pins.

The maximum allowed variation of the outside-to-outside distance of end holes in tension members and the inside-to-inside distance of end holes in compression members is 1/32 inch from that specified. Bore pin holes in built-up members after the member has been assembled.

(b) Threads for Bolts and Pins. Provide threads on all bolts and pins for structural steel construction that conform to the Unified Standard Series UNC ANSI B1.1, Class 2A for external threads and Class 2B for internal threads; but when pin ends have a diameter of 1 3/8 inches or more, provide six threads per inch.

555.12 Eyebars. Pin holes may be flame cut at least 2 inches smaller in diameter than the finished pin diameter. Securely fasten together (in the order to be placed on the pin) all eyebars that are to be placed side by side in the structure and bore at both ends while clamped. Pack and match-mark eyebars for shipment and erection. Stamp with steel stencils, so as to be visible when the bars are nested in place on the structure, all identifying marks on the edge of one head of each member after fabrication is completed. Use low-stress-type steel die stamps.

Provide eyebars, straight and free from twists, with pin holes accurately located on the centerline of the bar. Do not allow the inclination of any bar to the plane of the truss to exceed 5/8 inch per foot.

Simultaneously cut the edges of eyebars that lie between the transverse centerline of their pin holes with two mechanically operated torches abreast of each other, guided by a substantial template to prevent distortion of the plates.

555.13 Assembly - Bolting. Clean surfaces of metal in contact before assembling. Assemble parts of a member. Securely pin and firmly draw together before beginning drilling, reaming, or bolting. Take assembled pieces apart, if necessary, for the removal of burrs and shavings produced by the operation. Assemble members so that they are free from twists, bends, and other deformation.

Drift during assembling only enough to bring the parts into position without enlarging holes or distorting the metal.

555.14 Welded Connections. Fabricate surfaces and edges to be welded smooth, uniform, clean, and free of defects that would adversely affect the quality of the weld. Prepare edge in accordance with ANSI/AASHTO/AWS Bridge Welding Code D1.5.

555.15 Preassembly of Field Connections. Preassemble field connections of main members of trusses, arches, continuous beams, plate girders, bents, towers, and rigid frames before erection to verify the geometry of the completed structure or unit and to verify or prepare field splices. Present the method and details of preassembly for approval.

Use methods and details of preassembly that are consistent with the procedure shown on the approved erection camber diagrams. Assemble all girders and beams in their cambered (no-load) condition.

When members are assembled with their webs vertical, support them at intervals of 20 feet, or two-tenths of the span length, whichever is less. When the webs are horizontal, the above intervals of support may be increased, provided there is no noticeable deflection between points of support.

Assemble trusses in full dead-load position, unless the design of the structure provides for the secondary stresses created by assembling the truss in the fully cambered (no-load) position. Support trusses during assembly at each panel point. Preassemble at least three contiguous panels that are accurately adjusted for line and camber. For successive assemblies, include at least one section or panel of the previous assembly (repositioned if necessary and adequately pinned to assure accurate alignment) plus two or more sections or panels added at the advancing end. For structures longer than 150 feet, make each assembly not less than 150 feet long, regardless of the length of individual continuous panels or sections. Assembly may start from any location in the structure and proceed in one or both directions, as long as the preceding requirements are satisfied.

(a) Bolted Connections. Where applicable, assemble major components with milled ends of compression members in full bearing and then ream subsized holes to the specified size while the connections are assembled.

(b) Check Assembly—N/C Drilling. When using N/C drilling or punching, make a check assembly for each major structural type of each project. Fabricate the check assembly of at least three contiguous shop sections or, for a truss, all members in at least three contiguous panels, but not less than the number of panels associated with three contiguous chord lengths (such as the length between field splices). Base check

assemblies on the proposed order of erection, joints in bearings, special complex points, and similar considerations. Shop assemblies other than the check assemblies are not required.

If the check assembly fails in some specific manner to demonstrate that the required accuracy is being obtained, further check assemblies may be required.

Receive approval of each assembly (including camber, alignment, accuracy of holes, and fit of milled joints) before reaming is commenced or before any N/C-drilled check assembly is dismantled.

(c) Field-Welded Connections. Field-welded connections are prohibited unless specifically SHOWN ON THE DRAWINGS. Verify the fit of members (including the proper space between abutting flanges) with the preassembled segment.

(d) Match-Marking. Match-mark connecting parts preassembled in the shop to assure proper fit in the field. Provide a diagram showing such match-marks.

555.16 Connections Using Unfinished, Turned, or Ribbed Bolts. Use unfinished, turned, or ribbed bolts, where specified, that conform to ASTM A 307 for Grade-A bolts. Use bolts with approved single self-locking nuts or double nuts. Use beveled washers where bearing faces have a slope of more than 1:20 with respect to a plane normal to the bolt axis.

(a) Turned Bolts. Furnish turned bolts with a body-surface ANSI roughness not exceeding 125 micro inches. Furnish hex-headed bolts and nuts of the nominal size specified. Carefully ream holes for turned bolts, and furnish bolts to provide for a light driving fit. Keep bolt threads entirely outside of the holes. Provide a washer under the nut.

(b) Ribbed Bolts. Use approved form of ribbed body with continuous longitudinal ribs. Provide a body diameter measured on a circle through the points of the ribs 1/16 inch greater than the nominal diameter specified for the bolts.

Furnish ribbed bolts with round heads conforming to ANSI B18.5. Furnish hexagonal nuts that are either recessed or have a washer of suitable thickness. Furnish ribbed bolts that have a driving fit when installed in holes. Provide sufficiently hard ribs such that the ribs do not compress, deform, or allow the bolts to turn in the holes during tightening. If the bolt twists before drawing tight, ream the hole and provide an oversized replacement bolt.

555.17 Connections Using High-Strength Bolts. Assemble structural joints using AASHTO M 164 or M 253 high-strength bolts, or equivalent fasteners, as SHOWN ON THE DRAWINGS, tightened to a high tension.

(a) Bolted Parts. Use steel material within the grip of the bolt with no compressible material such as gaskets or insulation. Fabricate bolted steel parts to fit solidly together

after the bolts are tightened. Limit the maximum slope of the surfaces of parts in contact with the bolt head or nut to 1:20 with respect to a plane normal to the bolt axis.

(b) Surface Conditions. At the time of assembly clean all joint surfaces (including surfaces adjacent to the bolt head and nut) of dirt or foreign material and scale, except tight mill scale. Remove burrs that would prevent solid seating of the connected parts in the snug-tight condition.

Paint or other coatings are not permitted on the faying surfaces of slip-critical connections. All connections are considered to be slip-critical, unless otherwise SHOWN ON THE DRAWINGS. Exclude paint (including any inadvertent overspray) from areas closer than one bolt diameter, but not less than 1 inch, from the edge of any bolt hole and all areas within the bolt pattern.

(c) Installation. Install fasteners of the same lot number together. Protect fasteners from dirt and moisture. Take from protected storage only as many fasteners as are anticipated to be installed and tightened during a work shift. Return to protected storage fasteners not used at the end of the shift. Do not clean lubricant from fasteners where the lubricant is required to be present in the as-delivered condition. Clean and relubricate, before installation, fasteners for slip-critical connections that accumulate rust or dirt.

Provide a tension-measuring device (a Skidmore-Wilhelm calibrator or other acceptable bolt-tension-indicating device) at all job-sites where high-strength fasteners are being installed and tightened. Use the tension-measuring device to perform the rotational-capacity test and to confirm all of the following:

- The requirements of Table 555-6 of the complete fastener assembly.
- The calibration of the wrenches, if applicable.
- The understanding and proper use of the tightening method.

For short grip bolts, direct tension indicators (DTI's) with solid plates may be used to perform this test. First check the DTI with a longer grip bolt in the Skidmore- Wilhelm calibrator. The frequency of confirmation testing, number of tests to be performed, and test procedure shall conform to Subsection 555.17(c)(3) through (5), as applicable. Confirm the accuracy of the tension-measuring device through an approved testing agency at least once per year.

Install fasteners together with washers of the size and quality specified, located as required below, in properly aligned holes and tightened using any of the methods described in Subsection 555.17(c)(3) through (6) to at least the minimum tension specified in Table 555-6 after all the fasteners are tight.

If approved, tightening may be performed by turning the bolt while the nut is prevented from rotating when it is impractical to turn the nut. If impact wrenches are used, provide adequate capacity and sufficient air to tighten each bolt in approximately 10 seconds.

Table 555-6. - Minimum fastener tension.[a]

Bolt Size (inches)	AASHTO M 164 (pounds)	AASHTO M 253 (pounds)
1/2	12,000	15,000
5/8	19,000	24,000
3/4	28,000	35,000
7/8	39,000	49,000
1	51,000	64,000
1 1/8	56,000	80,000
1 1/4	71,000	102,000
1 3/8	85,000	121,000
1 1/2	103,000	148,000

[a] Equal to 70 percent of the specified minimum tensile strength of bolts (as specified for tests of full-size ASTM A 325 and ASTM A 490 bolts), rounded to the nearest 1,000 pounds.

Do not reuse AASHTO M 253 fasteners and galvanized AASHTO M 164 fasteners. If approved, other AASHTO M 164 bolts may be reused once. Touching up or retightening previously tightened bolts that may have been loosened by the tightening of adjacent bolts will not be considered to be reuse, provided the snugging up continues from the initial position and does not require greater rotation, including the tolerance, than that specified in Table 555-7.

Table 555-7.[a] - Nut rotation from the snug-tight condition.[b]

Bolt length Measured from Underside of Head to End of Bolt	Geometry of Outer Faces of Bolted Parts		
	Both faces normal to bolt axis	One face normal to bolt axis and other face sloped not more than 1:20. (Beveled washer not used)	Both faces sloped not more than 1:20 from normal to bolt axis. (Bevel washers not used)
Up to and including 4 diameters	1/3 turn	½ turn	2/3 turn
Over 4 diameters but not exceeding 8 diameters	½ turn	2/3 turn	5/6 turn
Over 8 diameters but not exceeding 12 diameters[c]	2/3 turn	5/6 turn	1 turn

[a] Applicable only to connections where all material within the grip of the bolt is steel.
[b] Nut rotation is relative to bolt, regardless of the element (nut or bolt) being turned. The tolerance is ± 30° for bolts installed by 1/2 turn or less. The tolerance is ± 45° for bolts installed by 2/3 turn or more.
[c] Determine the required rotation by actual tests in a suitable tension device simulating the actual conditions.

(1) Rotational-Capacity Tests. Subject high-strength fasteners, black and galvanized, to jobsite rotational-capacity tests performed in accordance with AASHTO M 164, subsection 8.5, and the following:

(a) After tightening to a snug-tight condition, as defined in Subsection 555.17(c) (3), tighten the fastener twice the required number of turns indicated in Table 555-7, in a Skidmore-Wilhelm calibrator or equivalent tension-measuring device, without stripping or failure.

(b) During this test, the maximum recorded tension must be equal to or greater than the turn test tension, which is 1.15 times the required minimum fastener tension indicated in Table 555-6.

(c) Ensure that the measured torque at a tension *P*, after exceeding the turn test tension required above, does not exceed the value obtained by the following equation:

$$Torque = 0.25PD$$

where

Torque = measured torque in foot-pounds
P = measured bolt tension in pounds
D = nominal bolt diameter in feet

For rotational-capacity tests, use washers even though their use may not be required in the actual installation.

(2) Washers. Where the outer face of the bolted parts has a slope greater than 1:20 with respect to a plane normal to the bolt axis, use a hardened beveled washer to compensate for the lack of parallelism.

Use hardened square or rectangular beveled washers for American Standard Beams and Channels conforming to AASHTO M 293.

Where necessary, washers may be clipped on one side not closer than seven-eighths of the bolt diameter from the center of the washer.

Hardened washers are not required for connections using AASHTO M 164 and M 253 bolts except under the following conditions:

(a) Use hardened washers under the element turned in tightening when the tightening is done by the calibrated wrench method.

(b) Use hardened washers under both the head and the nut when AASHTO M 253 bolts are installed in material with a specified yield point less than 40 kips per square inch, regardless of the tightening method.

(c) Use a hardened washer conforming to ASTM F 436 where AASHTO M 164 bolts of any diameter or AASHTO M 253 bolts equal to or less than 1 inch in diameter are to be installed in oversize or short-slotted holes in an outer ply.

(d) Use hardened washers conforming to ASTM F 436, except with 5/16 inch minimum thickness, under both the head and the nut in lieu of standard thickness hardened washers where AASHTO M 253 bolts over 1 inch in diameter are to be installed in an oversize or short-slotted hole in an outer ply. Multiple hardened washers with combined thickness equal to or greater than 5/16 inches do not satisfy this requirement.

(e) Where AASHTO M 164 bolts of any diameter or AASHTO M 253 bolts equal to or less than 1 inch in diameter are installed in a long-slotted hole in an outer ply, provide a plate washer or continuous bar that has a thickness of at least 5/16 inch, with standard holes of sufficient size to cover the slot after installation, and is of structural-grade material that need not be hardened.

When AASHTO M 253 bolts over 1 inch in diameter are used in long-slotted holes in external plies, use a single hardened washer conforming to ASTM F 436 with an 5/16 inch minimum thickness in lieu of washers or bars of structural steel. Multiple hardened washers with combined thickness equal to or greater than 5/16 inch do not satisfy this requirement.

Alternate design fasteners conforming to Subsection 717.01, with a geometry that provides a bearing circle on the head or nut with a diameter equal to or greater than the diameter of hardened washers conforming to ASTM F 436, satisfy the requirements for washers specified herein and may be used without washers.

(3) Turn-of-Nut Tightening. At the start of work, test nut tightening using a device capable of indicating bolt tension. Test not less than three bolt-and-nut assemblies of each diameter, length, and grade to be used in the work. Demonstrate with the test that the method to be used for estimating the snug-tight condition and controlling the turns from snug tight develops a tension not less than 5 percent greater than the tension specified in Table 555-6. Perform periodic retesting when required.

Install bolts in all holes of the connection and initially tighten to a snug-tight condition. Snug tight is defined as the tightness that exists when the plies of the joint are in firm contact. This may be attained by a few impacts of an impact wrench or the full effort of a worker using an ordinary spud wrench.

Systematically snug-tighten bolt groups from the most rigid part of the connection to the free edges. Then retighten the bolts of the connection in a similar systematic manner as necessary until all bolts are snug tight and the connection is fully compacted. Following the snug-tightening operation, tighten all bolts in the connection by the applicable amount of rotation specified in Table 555-7.

During all tightening operations, do not allow rotation of the fastener part not turned by the wrench. Tighten systematically from the most rigid part of the joint to its free edges.

(4) Calibrated Wrench Tightening. Calibrated wrench tightening may be used only when installation procedures are calibrated on a daily basis and when a hardened washer is used

under the element turned in tightening. Standard torques taken from tables or from formulas that assume to relate torque to tension are not acceptable.

If calibrated wrenches are used for installation, set them to provide a tension not less than 5 percent in excess of the minimum tension specified in Table 555-6. Calibrate the installation procedure at least once each working day for each bolt diameter, length, and grade using fastener assemblies that are being installed in the work.

Perform the calibration with a device capable of indicating actual bolt tension by tightening three typical bolts of each diameter, length, and grade from the bolts and washers being installed using a job-supplied washer under the element turned in tightening. Recalibrate wrenches when significant difference is noted in the surface condition of the bolts, threads, nuts, or washers. Verify during use that the wrench adjustment selected by the calibration does not produce a nut or bolt head rotation from snug tight greater than permitted in Table 555-7. Turn nuts in the tightening direction when measuring the torque of manual torque wrenches.

If calibrated wrenches are used to install bolts in a connection, install bolts with hardened washers under the turned element. When tightening bolts in all holes of the connection, tighten to a snug-tight condition. Following this initial tightening operation, tighten all bolts in the connection using a calibrated wrench. Tighten systematically from the most rigid part of the joint to its free edges. “Touch up” previously tightened bolts that may have been relaxed during the subsequent tightening of adjacent bolts until all bolts are properly tightened.

(5) DTI Tightening. When tightening bolts using DTI devices, assemble a representative sample of not less than three devices for each diameter and grade of fastener to be used in the work in a calibration device capable of indicating bolt tension. Include in the test assembly flat-hardened washers, if required in the actual connection, arranged like those in the actual connections to be tensioned. The calibration test must demonstrate that the device indicates a tension not less than 5 percent greater than that specified in Table 555-6.

Follow the manufacturer’s installation procedures for installation of bolts in the calibration device and in all connections. Give special attention to proper installation of flat-hardened washers when DTI devices are used with bolts installed in oversize or slotted holes, and where the load-indicating devices are used under the turned element.

When bolts are installed using DTI’s conforming to ASTM F 959, install bolts in all holes of the connection and bring to a snug-tight condition. Snug tight is indicated by partial compression of the DTI protrusions. Then tighten all fasteners systematically from the most rigid part of the connection to the free edges in a manner that will minimize relaxation of previously tightened fasteners. Comply with the installation instructions portion of Section 11.5.6.4.7, Division II, of AASHTO’s “Standard Specifications for Highway Bridges.” Proper tensioning of the bolts may require more than a single cycle of systematic partial tightening before final tightening to deform the protrusion to the specified gap.

(6) Installation of Alternate Design Bolts. When fasteners that incorporate a design feature intended to indirectly indicate the bolt tension or to automatically provide the tension specified in Table 555-6 and that conform to Subsection 717.01 are to be installed, test a representative sample of not less than three bolts of each diameter, length, and grade at the jobsite with a device capable of indicating bolt tension.

Include in the test assembly flat-hardened washers, if required in the actual connection, arranged as in the actual connections to be tensioned. The calibration test must demonstrate that each bolt develops a tension not less than 5 percent greater than the tension specified in Table 555-6. Follow manufacturer's installation procedure. Perform periodic retesting when required.

When alternate design fasteners that are intended to control or indicate bolt tension of the fasteners are used, install bolts in all holes of the connection and initially tighten sufficiently to bring all plies of the joint into firm contact, but without yielding or fracturing the control or indicator element of the fasteners. Continue to tighten systematically from the most rigid part of the connection to the free edges in a manner that will minimize relaxation of previously tightened fasteners.

Proper tensioning of the bolts may require more than a single cycle of systematic partial tightening before final twist-off or pull-off of the control or indicator element of individual fasteners.

(7) Inspection. Inspect the tightened bolts in the presence of the CO. Use an inspection torque wrench to verify tightening of threaded fasteners. For nonthreaded fasteners, ping each fastener with a hammer to test for soundness. Replace or retighten any loose or relaxed fastener. Cutting with a torch will not be permitted for removal of bolts.

Individually place three bolts of the same grade, size, and condition as those under inspection in a device calibrated to measure bolt tension. Perform this calibration operation at least once each inspection day. Permit the CO full opportunity to witness calibration tests.

Use a washer under the part turned in tightening each bolt if washers are used on the structure. If washers are not used on the structure, use the same specification material that abuts the part turned in the tension-measuring device as used on the structure. In the calibrated device, tighten each bolt by any convenient means to the specified tension. Apply the inspecting wrench to the tightened bolt to determine the torque required to turn the nut or head 5 degrees, approximately 1 inch at a 12-inch radius, in the tightening direction. Use the average of the torque required for all three bolts as the job-inspection torque.

Select at random in each connection 10 percent (at least two) of the tightened bolts on the structure represented by the test bolts, and apply the job-inspection torque to each selected bolt with the inspecting wrench turned in the tightening direction. If this torque turns no bolt head or nut, the bolts in the connection will be considered to be properly tightened. If the torque turns one or more bolt heads or nuts, apply the job-inspection torque to all bolts in the connection. Tighten and reinspect any bolt whose head or nut

turns at this stage. As an option, retighten all bolts in the connection and resubmit for inspection.

555.18 Welding. Ensure that welding, welder qualifications, prequalification of weld details, and inspection of welds conform to ANSI/AASHTO/AWS Bridge Welding Code D 1.5. Delete the provisions of Section 9.25.1.7. Do not underrun the nominal fillet weld size.

Do not weld or tack brackets, clips, shipping devices, or other material not required to any member unless SHOWN ON THE DRAWINGS.

555.19 Erection. Ensure that falsework and forms conform to Section 562.

(a) Handling & Storing Material. Place material stored at the jobsite on skids above ground. Keep material clean and properly drained. Place and shore girders and beams upright. Support long members, such as columns and chords, on skids placed near enough together to prevent damage due to deflection.

(b) Bearings & Anchorages. Furnish and install bridge bearings in accordance with Section 564. If the steel superstructure is to be placed on a substructure that was built under a separate contract, verify that the masonry has been correctly constructed before ordering material.

(c) Erection Procedures. Follow the procedures shown below.

(1) Conformance to Drawings. Erect as SHOWN ON THE DRAWINGS. Modifications to or deviations from the approved erection procedure will require revised drawings and verification of stresses and geometry.

(2) Erection Stresses. Allow for erection stresses induced in the structure as a result of the use of a method of erection or equipment that differs from that previously approved, and that will remain in the finished structure as locked-in stresses. Provide additional material, as needed, to keep both temporary and final stresses within the allowable limits used in the design.

Provide temporary bracing or stiffening devices to accommodate handling stresses in individual members or segments of the structure during erection.

(3) Maintaining Alignment & Camber. During erection, support segments of the structure in a manner that will produce the proper alignment and camber in the completed structure. Install cross frames and diagonal bracing as necessary during erection to provide stability and assure correct geometry. As necessary, provide temporary bracing at any stage of erection.

(d) Field Assembly. Accurately assemble as SHOWN ON THE DRAWINGS and required by match-marks. Carefully handle the material. Do not hammer, damage, or distort the members. Clean bearing surfaces and permanent contact surfaces before assembly.

Assemble splices and field connections with at least two cylindrical erection pins per part (a minimum of four per splice or connection). Use cylindrical erection pins 1/32 inch larger than the bolts to be used. A plate girder splice requires, for example, at least four cylindrical erection pins for the top flange splice, four pins for the web splice, and four pins for the bottom flange splice. (These provide two pins for each part.) Place the pins in the corner holes of the splice plates.

Install more cylindrical erection pins, if necessary, to accurately align the parts. Fill the remaining holes in the connection with bolts, and tighten systematically in accordance with Subsection 555.17 from the most rigid part of the connection to the free edges. Remove cylindrical erection pins and replace with tightened bolts.

Release temporary erection supports at a splice or connection only after all bolts are installed and tightened. Special assembly and support situations are SHOWN ON THE DRAWINGS or approved submittals.

Fitting-up bolts may be the same high-strength bolts used in the installation. If other fitting-up bolts are required, use the same nominal diameter as the high-strength bolts.

(e) Pin Connections. Use pilot and driving nuts in driving pins. Drive the pins so that the members will fully bear on the pins. Screw pin nuts tight, install nut retaining devices as SHOWN ON THE DRAWINGS, and burr the threads at the face of the nut with a pointed tool.

(f) Misfits. Correction of minor misfits involving minor amounts of reaming, cutting, and chipping may be done, if approved. Any error in the shop fabrication or deformation resulting from handling and transporting will be cause for rejection.

Measurement

555.20 Method. Use the method of measurement that is DESIGNATED IN THE SCHEDULE OF ITEMS.

Measure structural steel by the pound or lump sum computed in accordance with the AASHTO “Standard Specifications for Highway Bridges.” The quantity will include metal items incidental to the structure, such as castings, steel plates, anchor bolts and nuts, bearings, rockers, rollers, pins and nuts, expansion dams, roadway drains and scuppers, weld metal, bolts embedded in concrete, cradles and brackets, posts, conduits and ducts, and structural shapes.

Changes in quantities resulting from alternative details proposed by the Contractor and approved by the CO are not subject to price adjustment.

Payment

555.21 Basis. The accepted quantities will be paid for at the contract unit price for each PAY ITEM DESIGNATED IN THE SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item		**Pay Unit**
555(01)	Structural steel, _____, furnished, *Description* fabricated, and erected	Pound
555(02)	Structural steel, _____, furnished, *Description* fabricated, and erected	Lump Sum

Section 556 - Bridge Railing

Description

556.01 Work. Furnish and erect and/or remove and reset bridge railing and bridge approach railing.

Bridge railing is designated as concrete, steel, aluminum, or timber in accordance with the predominant material contained in the railing.

Materials

556.02 Requirements. Furnish material that conforms to specifications in the following sections and subsections:

Aluminum Bolt Heads and Nuts	717.14
Aluminum Alloy for Bridge Rail	717.13
Aluminum-Impregnated Caulking Compound	725.27
Aluminum Welding Wire	717.15
Box Beam Rail	710.07
Guardrail	606
Painting	563
Reinforcing Steel	554
Steel Structures	555
Structural Concrete	552
Timber Structures	557

Construction

556.03 General. Accurately place anchor bolts to provide correct and true alignment of the railing. Set anchor bolts so that they project not more than 3/8 inches beyond the nut when tightened. Chamfer or round by grinding or filing all sharp exposed metal edges.

Provide bridge rail shop drawings when SHOWN ON THE DRAWINGS or called for in the SPECIAL PROJECT SPECIFICATIONS.

Do not erect railing until centering or falsework for the supporting span is removed. Construct bridge railing so that it does not follow any unevenness in the curb, sidewalk, or wall that supports the railing. The railing shall present a smooth, uniform appearance in its final position. Set all posts vertical.

556.04 Concrete Railing. Construct in accordance with Section 552 and the following:

- Construct expansion joints that permit freedom of movement. After all other work is completed, use a sharp chisel to remove all loose or thin shells of concrete likely to spall under movement at expansion joints.

(a) Fixed Forms. Construct forms that are smooth and tight fitting, rigidly held in line and grade, and removed without damage to the concrete. Make form joints in vertical planes. Construct all moldings, panel work, and bevel strips as SHOWN ON THE DRAWINGS. Make corners in the finished work true and free from cracks, spalls, or other defects.

(b) Slipformed. Concrete rails may be slipformed if the DRAWINGS contain details for slipforming. Before slipforming any permanent rail, one or both of the following requirements shall be met, as directed by the CO:

(1) Cast a test section at least 20 feet long that shall:

(a) Be placed off the structure.

(b) Have the same section and reinforcement as detailed for use on the structure.

(c) Include one typical contraction or open joint.

(d) Be removed and disposed of without compensation.

(2) Identify, for the purposes of evaluating work quality, at least two recent slipformed rail projects completed by the Contractor.

The CO will make the final decision about the use of slipforming on the project based on work quality. If slipforming is approved by the CO:

- Provide concrete with a slump of 1-inch ± 1/2 inch.
- Keep the top and faces of the finished rail free from sags, humps, and other irregularities.
- Maintain contraction joints, open joints, and expansion joints to the dimensions SHOWN ON THE DRAWINGS until the concrete sets.
- Use slipforming only for section of rail with constant dimensions. Use fixed forms where dimensions vary, as at luminaire or signal supports and at rail end transitions.
- Brush finish exposed rail surfaces with vertical strokes. Do not grind brush finished surfaces that are to receive a Class 1 finish as specified in Subsection 552.18(a).
- Remove and replace any unsatisfactory work without compensation.

(***c) Surface Finish.*** Apply a general surface finish using a Class 2 finish to all exposed concrete surfaces as specified in Subsection 552.18(b).

556.05 Steel Railing. Construct in accordance with Section 555. Ensure that structural tubing conforms to AASHTO M 183 (ASTM A 500, Grade B).

If required, galvanize in accordance with AASHTO M 111, and furnish nuts, bolts, and washers galvanized in accordance with AASHTO M 232. Repair minor abrasions with zinc-rich paint.

For exposed weathering steel, use railing fasteners, railing hardware, rail post anchor bolts, nuts, washers, and shims with the same atmospheric corrosion resistance and weathering characteristics as the railing and posts. Use hand methods to clean erected steel railing of all oil, dirt, grease, mortar, and other foreign substances. Use weld metal with similar atmospheric corrosion resistance and coloring characteristics as the base metal. Clean welds by power brushing or blast cleaning to remove welding flux, slag, and spatter.

Unless a coating is required, clean all weathering steel in accordance with Steel Structures Painting Council (SSPC) standard SSPC–SP 6 and remove all mill scale and other foreign substances so that the steel surface is uniformly exposed to the atmosphere.

556.06 Aluminum Railing. Construct in accordance with Section 555, except as amended by the following:

(a) Cutting. Material that is 1/2 inch thick or less may be cut by shearing, sawing, or milling. Saw or mill material that is more than 1/2 inch thick. Do not flame cut. Make cut edges true, smooth, and free from excessive burrs or ragged breaks. Fillet re-entrant cuts by drilling before cutting.

(b) Bending. Material may be heated to a maximum 390 °F for a period not to exceed 30 minutes to facilitate bending.

(c) Rivet & Bolt Holes. Drill rivet and bolt holes to finished size or subpunch smaller than the nominal diameter of the fastener and ream to size. Subpunch to a diameter that is smaller than that of the finished hole by at least one-quarter the thickness of the piece. Make the finished diameter of holes not more than 7 percent greater than the nominal diameter of the fastener, except:

(1) Fabricate slotted bolt holes as required.

(2) Fabricate anchor bolt holes up to 25 percent larger, not to exceed 9/16 inches larger than the nominal bolt diameter.

(d) Welding. Weld in accordance with AWS Structural Aluminum Welding Code D 1.2.

(e) Contact With Other Material. Do not place aluminum alloys in contact with copper, copper base alloys, lead, or nickel. Where aluminum alloys come in contact with other metals, coat the contacting surfaces thoroughly with an approved aluminum-impregnated caulking compound or place a neoprene gasket between the surfaces.

Where aluminum alloys come in contact with concrete or stone, coat the contacting surfaces with an aluminum-impregnated caulking compound. When bond between aluminum and concrete is required, coat the aluminum with zinc-chromate paint and allow to dry before installation.

Where aluminum alloys come in contact with wood, coat the contacting wood surface with three coats of paint in accordance with Section 563 and coat the contacting aluminum surface with an aluminum caulking compound.

556.07 Timber Railing. Construct in accordance with Section 557.

When SHOWN ON THE DRAWINGS or directed in the SPECIAL PROJECT SPECIFICATIONS, clean all exposed surfaces of timber railing treated with pentachlorophenol or creosote that are located where contact by people may occur. Seal these surfaces with two coats of urethane, shellac, latex epoxy, enamel, or varnish.

556.08 Approach Railing. Construct in accordance with Subsection 556.05 and Section 606.

556.09 Remove & Reset Bridge Railing. Remove and store the existing bridge railings and appurtenances. Replace all railings, supports, and hardware damaged during removal, storage, or resetting.

556.10 Painting. Paint in accordance with Section 563.

Measurement

556.11 Method. Use the method of measurement that is DESIGNATED IN THE SCHEDULE OF ITEMS.

Measure bridge railing by the linear foot or by the lump sum. Measure removed and reset bridge railing by the linear foot. When bridge railing is measured by the linear foot, measure along the top of the railing center to center of end posts.

When bridge approach railing is measured by the linear foot, measure the total approach railing length along the face of the railing from the ends of the bridge railing, as SHOWN ON THE DRAWINGS, to the center of the end approach railing posts, unless otherwise SHOWN ON THE DRAWINGS.

Payment

556.12 Basis. The accepted quantities will be paid for at the contract unit price for each PAY ITEM DESIGNATED IN THE SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item		**Pay Unit**
556(01)	_____ bridge railing	Liner Foot
556(02)	_____ bridge railing	Lump Sum
556(03)	Remove and reset bridge railing	Linear Foot
556(04)	Bridge approach railing, type , _____, class_____	Linear Foot
556(05)	Terminal section, _____ *Description*	Each
556(06)	Anchorage	Each

Section 557 - Timber Structures

Description

557.01 Work. Furnish, fabricate, erect, and paint structural timber, including all required yard lumber and hardware.

Materials

557.02 Requirements. Furnish material that conforms to specifications in the following section and subsections:

Hardware & Structural Steel 716.02
Painting 563
Structural Glued Laminated Timber 716.04
Treated Structural Timber & Lumber 716.03
Treated Timber Piles 715.02
Untreated Structural Timber & Lumber 716.01

Furnish the following compliance certificates to the CO upon delivery of the materials to the jobsite:

(a) Verification of compliance with grading rules and species of timber and lumber. Provide certification by an agency accepted as competent by the American Lumber Standards Committee (ALSC).

(b) Lot certification of each charge for preservative, penetration in inches, and retention in pounds per cubic foot (assay method) by a qualified independent inspection and testing agency. In addition, have the producer of the treated products provide written certification that Best Management Practices (BMP's) in accordance with "Best Management Practices for Treated Wood in Western Aquatic Environments," published by the Western Wood Preservation Institute (WWPI) and Canadian Institute of Treated Wood, were followed, including a description and appropriate documentation of the applicable BMP's used.

(c) Certification from a qualified inspection and testing agency indicating that all glued laminated members are in accordance with the requirements of American National Standard for Wood Products, "Structural Glued Laminated Timber" (ANSI/AITC A190.1), modified as SHOWN ON THE DRAWINGS.

(d) Such other certifications as SHOWN ON THE DRAWINGS or called for in the SPECIAL PROJECT SPECIFICATIONS.

Incise all glued laminated and solid sawn members thicker than 2 inches in accordance with AWPA standard C1, unless otherwise SHOWN ON THE DRAWINGS.

Provide shop drawings for all timber 21 days in advance of fabrication when SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS. Show all dimensions and fabrication details for all cut, framed, or bored timbers.

Construction

557.03 General. Perform the work under Section 206. Furnish structural lumber and timber of the required stress grade.

Clear stacks of weeds, rubbish, or other objectionable material from the ground under and in the vicinity of all stored material. Place the bottom layer of material at least 8 inches above the ground level. Provide sufficient support to prevent sagging.

Open-stack untreated material to shed water. Stack material in layers on spacers (stickers) that extend across the full width of the stack to allow for free air circulation. Align all stickers vertically and space them at regular intervals.

Close-stack treated material to shed water.

Protect material from the weather. If covered, use sheet material such as water-resistant paper or opaque polyethylene film. Do not cover with impervious membranes, such as polyethylene film, during dry weather. Slit individual wrappings full length or puncture on the lower side to permit drainage of water.

Store and protect glued laminated timber in accordance with the recommendations for Loading and Handling, Job Site Storage, and Erection in "Recommended Practice for Protection of Structural Glued Laminated Timber During Transit, Storage, and Erection," published by the American Institute of Timber Construction, AITC 111.

Use slings or other devices to protect corners of heavy construction timbers and banded packages of lighter construction timber.

557.04 Treated Timber. Fabricate timbers before treatment. Handle treated timber according to the Consumer Information Sheet published by AWPA. Do not cut, frame, or bore treated timber after treatment unless approved by the CO. Handle treated timbers carefully and do not drop, damage outer fibers, or penetrate the surface with tools. Do not use cant dogs, hooks, or pike poles. In coastal waters, do not cut or bore timber below the high-water mark.

For timbers originally treated with pentachlorophenol, creosote, creosote solutions, or waterborne preservatives, field treat all cuts, abrasions, bolt holes, and recesses that occur after treatment with two liberal applications of a compatible preservative in accordance with the requirements specified in AWPA standard M4, Standard for the Care of Pressure-Treated Wood Products.

Unless otherwise specified, copper naphthenate solutions may be used for field treatments of material originally treated with copper naphthenate, pentachlorophenol, creosote, creosote solution, or waterborne preservatives. Prepare the preservative solution

by blending copper naphthenate preservative that meets P8 requirements with a solvent conforming to AWPA standard P9. Ensure that the resulting preservative solution concentration contains a minimum of 2 percent copper metal.

Plug all unused holes with preservative-treated plugs. Perform all field-applied preservative treatment with necessary precautions so as to prevent any soil and/or water contamination.

557.05 Untreated Timber. Coat the following untreated timber surfaces in accordance with AWPA standard M4:

(a) All ends and tops, and all contact surfaces of posts, sills, and caps.

(b) All ends, joints, and contact surfaces of bracing and truss members.

(c) All surfaces of timber bumpers and the back faces of bulkheads.

(d) All other timber that will be in contact with earth.

557.06 Workmanship. Cut and form all lumber and construction timber so all joints will have even bearing over the entire contact surface. Do not use shims in making joints. Construct all joints to be closed. Drive nails and spikes to set the heads flush with the wood surface. Use the same end, face, and edge of the timber member for all layout dimensions. Bore all holes from mating faces.

557.07 Holes for Bolts, Dowels, Rods, & Lag Screws. Bore all holes before preservative treating the wood. Bore holes for round drift bolts and dowels 1/16 inch smaller in diameter than that of the bolt or dowel to be used. Ensure that the diameter of holes for square drift bolts or dowels is equal to the side dimension of the bolt or dowel.

Bore holes for machine bolts with a bit 1/16 inch larger than the diameter, except when galvanized bolts are specified. In this case, drill all holes 1/8 inch greater than the bolt size. Bore holes for lag screws with a bit not larger than the body of the screw at the base of the thread. Drill the depth of lag screw bolt holes 1 inch less than the length under the screw head and with a diameter approximately 75 percent of the shank diameter.

557.08 Hardware. Furnish the hardware as SHOWN ON THE DRAWINGS, as specified below.

(a) Bolts & Washers. Finally tighten all nuts to provide proper bearing, and cut off excess bolt lengths of more than 1 inch. After final tightening, check or burr all bolts effectively with a pointing tool to prevent loosening of the nuts.

Use malleable iron washers with a diameter approximately three times the bolt diameter under all bolt heads or nuts in contact with wood. Use cast-iron washers when the timber is in contact with the ground. Use square washers only when SHOWN ON THE DRAWINGS or with the approval of the CO.

(b) Galvanizing. Unless otherwise SHOWN ON THE DRAWINGS, ensure that all hardware for timber structures is galvanized, except for the glued laminated deck panel dowels. Ensure that all fasteners, including nails, spikes, bolts, washers, and timber connectors, other than malleable iron, are galvanized.

557.09 Countersinking. Countersink nuts and bolt heads where SHOWN ON THE DRAWINGS. Paint recesses formed for countersinking with an approved preservative, except in railing. After bolts or screws are in place, fill the holes with hot pitch or other approved filler.

557.10 Framing. Do not slab or trim treated piles for fitting sway or sash braces. Fill all gaps that occur between braces and piles with treated blocks so that the bracing is securely fastened to the piles.

557.11 Framing Bents. Bed mud sills firmly, evenly, and level to solid bearing, and tamp in place.

When concrete is cast and dowels are used for anchoring sills and posts, install dowels (3/4 inch minimum diameter) that project at least 6 inches above the tops of the pedestals. Carefully finish concrete pedestals supporting framed bents so that sills or posts bear evenly on the pedestals.

Provide firm, uniform bedding for mud sills. Make sills bear true and even on mud sills, piles, or pedestals. Drift bolt sills with bolts that extend into the mud sills or piles for at least 6 inches. Where possible, remove all earth in contact with sills for circulation of air around the sills.

557.12 Posts. Fasten posts to pedestals with dowels not less than ¾ inch in diameter that extend at least 6 inches into the posts, or with other types of connectors as SHOWN ON THE DRAWINGS. Fasten posts to sills using one of the following methods, as SHOWN ON THE DRAWINGS:

(a) With dowels not less than ¾ inch in diameter that extend at least 6 inches into posts and sills.

(b) With drift bolts not less than ¾ inch diameter driven diagonally through the base of the post and extending at least 7 inches into the sill. Drive drift bolts into holes at a 45° angle to enter the post at least 6 inches above the post base.

(c) With other types of connectors as SHOWN ON THE DRAWINGS.

557.13 Pile Bents. Treat, furnish, and drive piles in accordance with Section 551.

557.14 Caps for All Bents. Make timber caps bear even and uniform over the tops of the supporting posts or piles, with their ends in alignment. Secure all caps with drift bolts and set approximately at the center of and extending into the posts or piles at least 9 inches.

557.15 Bracing. Bolt the ends of bracing through the pile, post, cap, or sill. Brace intermediate intersections with posts or piles with bolts or spikes, as required. In all cases, use galvanized spikes in addition to bolts.

Make all bracing bear firmly against the pile or cap to which it is bolted. Provide and place shims as necessary to prevent bending the bracing more than 1 inch out of line when bracing bolts are tightened.

Where the space between the bracing and cap or pile is less than 1 inch, shims need not be used.

Where the space between the bracing and the cap or pile is 1 ½ inch ± 9/16 inches, place two ogee washers, with their narrow faces together, or other approved washers on each bolt that passes through the space.

Where the space between the bracing and the cap or pile is over 2 inches, use wooden shims of the proper thickness. Fabricate the wooden shims from White Oak or from other approved hardwood. Do not use built-up wooden shims. Make wooden shims from a single piece of lumber with the width not less than 4 inches and the length not less than the width of the bracing measured along the cap or pile. Do not adze, trim, or cut any treated member to avoid the use of shims.

557.16 Stringers. Place solid sawn stringers in position so that knots near edges are in the top portions of the stringers.

Outside stringers may have butt joints with the ends cut on a taper. Lap interior stringers to take bearing over the full width of the floor beam or cap at each end. Separate the lapped ends of untreated stringers by at least ½ inch for air circulation. Securely fasten the lapped ends with drift bolts, as required. Stagger the joints where stringers are two panels in length.

Install cross-bridging between stringers as SHOWN ON THE DRAWINGS. If timber cross-bridging members are used, cut for a full bearing at each end against the sides of the stringers. Place cross-bridging at the center of each span or as SHOWN ON THE DRAWINGS.

557.17 Plank Floors. Use plank that is surfaced on four sides (S4S).

Single-ply timber floors consist of a single thickness of planks supported on stringers. Lay the planks heart side down with 3/16 inches space between them for seasoned material, and with tight joints for unseasoned material. Spike each plank securely to each stringer. Carefully grade the planks as to thickness and lay so that no two adjacent planks vary in thickness by more than 1/16 inch.

Two-ply timber floors consist of two layers of flooring supported on stringers. Pressure treat the lower layer with creosote oil or with another preservative as SHOWN ON THE DRAWINGS. Lay the top layer either diagonal or parallel to the centerline of roadway as required. Securely fasten each floor piece to the lower layer. Stagger joints at least 3 feet.

Where the top layer is placed parallel to the centerline of the roadway, use special care to securely fasten the ends of the flooring. Bevel the ends of top layer members at each end of the structure.

557.18 Transversely Nail-Laminated Decks. Use 2 inch nominal thickness laminations; surface one edge hit or miss 1/8 inch scant (SIE–H or M 1/8 inch scant), and one side hit or miss 1/8 inch scant (SIS–H or M 1/8 inch scant).

Place the laminations on edge and at right angles to the centerline of the roadway. Spike each piece to the preceding piece at each end and at approximately 18-inch intervals, with the galvanized spikes driven alternately near the top and bottom edges. Use spikes of sufficient length to pass through two pieces and at least halfway through the third piece.

Where timber stringers are used, toenail every other piece to every other stringer. Use the size spikes specified. When steel stringers are used, securely attach the pieces using approved galvanized metal clips.

Use pieces of sufficient length to bear on at least four stringers. Do not splice pieces between stringers. Space end joints on any one stringer no closer than every third piece. Space end joints in adjoining pieces no closer than every second stringer.

557.19 Glued Laminated Panel Decks. Do not drag or skid panels. When lifted, support panels in the weak-moment plane at a sufficient number of points to avoid overstressing, and protect the edges from damage.

When dowels are SHOWN ON THE DRAWINGS between deck panels, use a template or drilling jig to ensure that dowel holes are accurately spaced and drilled parallel to one another and to the horizontal surfaces of the panel. Drill holes to a depth ¼ inch greater than one-half the dowel length, and of a diameter that is 1/16 inch greater than the dowel, unless otherwise SHOWN ON THE DRAWINGS. Use a temporary dowel as a check for snug fit prior to production drilling. Use dowels of the size SHOWN ON THE DRAWINGS, with the tips slightly tapered or rounded. Use an approved lubricant to facilitate the connection process.

Start the tips of all dowels partially and equally into the holes of the two panels being joined. Draw the panels together keeping the edges parallel, until the panels abut tightly. Securely fasten each panel to each stringer as SHOWN ON THE DRAWINGS.

Assemble and match-mark panels prior to delivery to the construction site when SHOWN ON THE DRAWINGS or called for in the SPECIAL PROJECT SPECIFICATIONS. Follow erection procedures given in FPL–263, Forest Service, Forest Products Laboratory (FPL), Madison, Wisconsin.

557.20 Wheel Guards & Railings. Surface (S4S) wheel guards, rails, and posts. Place wheel guards in sections not less than 12 feet in length. Squarely butt-joint all rails at posts.

557.21 Trusses. Fabricate trusses to show no irregularities of line when completed.

Fabricate chords straight and true from end to end in horizontal projection. In vertical projection, fabricate chords to a smooth chorded curve through panel points conforming to the correct camber. Do not make uneven or rough cuts at the points of bearing.

557.22 Drains. Hot-dip galvanize drains, including anchorages, after fabrication.

557.23 Painting. Paint in accordance with Section 563.

Measurement

557.24 Method. Use the method of measurement that is DESIGNATED IN THE SCHEDULE OF ITEMS.

Measure untreated and treated structural timber and lumber by the cubic foot of lumber and timber in place in the completed structure. Compute the quantities from nominal dimensions and actual lengths, except for transversely nail-laminated decks. Measure transversely nail-laminated decks in place after dressing.

Measure timber piles under Subsection 551.16.

Measure timber bridge rail under Subsection 556.11.

Measure structural excavation under Subsection 206.12.

Payment

557.25 Basis. The accepted quantities will be paid for at the contract unit price for each PAY ITEM DESIGNATED IN THE SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item		Pay Unit
557(01)	Untreated structural timber and lumber	Cubic Foot
557(02)	Treated structural timber and lumber	Cubic Foot
557(03)	Untreated structural timber and lumber	Lump Sum
557(04)	Treated structural timber and lumber	Lump Sum
557(05)	Treated structural timber, glued laminated	Cubic Foot
557(06)	Treated structural timber, glued laminated	Lump Sum

Section 558 - Prefabricated, Modular Bridge Superstructure

Description

558.01 Work. Design, fabricate, deliver, and install a prefabricated, modular bridge superstructure, or transport and install Government-furnished prefabricated, modular superstructure and components as DESIGNATED IN THE SCHEDULE OF ITEMS. Construct the length, width, and capacity of the structure, including curbs and railings and the horizontal and vertical alignment, as SHOWN ON THE DRAWINGS.

Also furnish material for, and construct, bridge railing as SHOWN ON THE DRAWINGS or on approved manufacturer's drawings. Unless components are furnished by the Government, furnish prefabricated, modular bridge superstructure components complete and in place, including deck and railing, when required, to form a bridge superstructure capable of supporting traffic as soon as construction of approaches is complete. Include all incidental materials required to provide a completed structure ready for use.

When there are specific requirements for design, materials, appearance, and/or construction, they shall be SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS.

Materials

558.02 Requirements. Furnish materials that meet the requirements specified in the following sections and subsections:

Bridge Railing	556
Hardware & Structural Steel	716.02
Precast Concrete Structures	553A
Prestressed Concrete	553
Reinforcing Steel	554
Steel Structures	555
Structural Concrete	552
Timber Structures	557

Concrete compressive strength, structural steel tensile strength, finish, designation, timber species, grade, treatment, and other material specifications shall be as SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS. If material specifications are not in the contract documents, take them from the manufacturer's drawings, and have them approved by the CO prior to fabrication.

558.03 Design Requirements. Design in accordance with the AASHTO "Standard Specifications for Highway Bridges," latest edition and interims, for the HS20–44 loading, including impact, unless otherwise SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS.

When design of the structure is required, provide on all the drawings and calculations that are submitted for review the signature and seal of a professional engineer who is currently licensed in the State where the bridge will initially be located.

Use materials that are durable enough to allow removal, transportation, and reinstallation using typical forest logging or construction equipment. Use design techniques and fabrication methods to minimize field erection difficulties. Fabricate primary components from steel unless otherwise SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS.

Rig main superstructure components with permanent lifting devices to facilitate efficient installation and removal of these items with equipment common to logging or construction operations. Place lifting devices so as not to interfere with traffic utilizing the structure.

558.04 Design Drawings. When furnishing a prefabricated bridge superstructure, submit design drawings, calculations, and/or shop drawings sufficiently in advance of the start of fabrication to allow time for review by the CO and correction of any changes. Such time shall be proportional to the work, but not less than 21 days. Include plan, elevation, and section views of the modular bridge superstructure, dimensions of all components, welding and connection details, and general and specific notes regarding design and construction.

When Government-furnished prefabricated bridge superstructure components are specified, material lists, erection information, and manufacturer's instructions will be furnished by the Government.

Construction

558.05 General. Perform excavation, backfill, and embankment work under Sections 203 and 206.

Dispose of all debris resulting from operations in accordance with Section 202.

Perform all construction of substructures, riprap, and signs under Sections 206, 206A, 251, 551, 552, 553A, 554, 555, 557, 564, 602, and 633, as applicable.

558.06 Performance. Provide 2 weeks' notice prior to delivery and/or installation.

If the prefabricated superstructure is not installed immediately upon delivery to the project site, provide appropriate equipment and labor to unload and stack, support, and store all material at the delivery point. Support and stack all components to prevent damage. Furnish and install blocking such that all components are supported at least 12 inches above the ground.

Furnish all tools, devices, special equipment, and material needed for installation in well-marked watertight containers suitable for long-term, outdoor storage.

558.07 Contractor-Furnished Prefabricated Bridge Superstructure. As applicable, furnish the CO with the following items for approval prior to delivery of the bridge component:

(a) Supplier or inspection agency certification of wood species and grade of all timber and a conformance certificate for all sawn and glued laminated members.

(b) Certification by an approved inspection and testing agency of wood treatment, listing method of treatment, type of preservative, retention, and penetration. Supplier certification is permitted if each piece is stamped or branded with a legible American Wood Preservers Bureau quality mark.

(c) Certification of structural steel, fasteners, and hardware.

(d) Certification of galvanizing process used.

(e) Steel fabricator certification that steel fabrication and quality control meet the requirements of the AISC Code of Standard Practice; and that all welding meets the requirements of ANSI/AASHTO/AWS D 1.5 Bridge Welding Code.

(f) A complete list of all bridge components, hardware, and fasteners.

(g) Complete erection instructions and drawings. Provide drawings that are black line, on a reproducible mylar media, on ANSI sheet size B or D.

As appropriate to the type of modular bridge, mark each major component of the bridge superstructure with the same serial number. Ensure that the marking is permanent and clearly visible on each component, both when stacked in storage and when erected on a bridge site.

When called for in the SPECIAL PROJECT SPECIFICATIONS, assemble each bridge superstructure prior to delivery to ensure proper fit-up of all components. Notify the CO of the assembly 2 weeks in advance so that inspection of the assembly can be arranged.

558.08 Government-Furnished Prefabricated Bridge Superstructure. When Government-furnished prefabricated bridge units are specified, transport all designated material from the storage site(s) designated in the SPECIAL PROJECT SPECIFICATIONS or SHOWN ON THE DRAWINGS to the bridge site, and install the superstructure complete and in place, including connection of all girders, diaphragms, railings, panels, transoms, and other elements.

Upon taking possession of the Government-furnished units at the storage site, assume all liability for damage resulting from handling, transporting, and/or erecting the units in place, until final acceptance of the project.

Measurement

558.09 Method. Use the method of measurement that is DESIGNATED IN THE SCHEDULE OF ITEMS.

Measure prefabricated bridge superstructures on a lump sum basis. Include all materials and work necessary to furnish, transport, and install the superstructure, including the deck and railing, as SHOWN ON THE DRAWINGS.

Payment

558.10 Basis. The accepted quantities will be paid for at the contract unit price for each PAY ITEM DESIGNATED IN THE SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item		Pay Unit
558(01)	Prefabricated bridge superstructure - design, fabricate, deliver, and install	Each
558(02)	Government-furnished prefabricated bridge superstructure - transport and install	Each

Section 559 - Log Bridges

Description

559.01 Work. Furnish, fabricate, and install the logs and timber for constructing log bridges, including abutments, piers, and superstructure. In addition, furnish and install all hardware and other required material.

Materials

559.02 Requirements. Furnish materials that conform to specifications in the following section and subsections:

Geotextiles	714.01
Reinforcing Steel	554
Structural Concrete	552
Timber Structures	557

559.03 Logs. Furnish logs used for stringers within the dimensional tolerance and of the species SHOWN ON THE DRAWINGS. They must be of high quality, straight, sound, and free of wind shake, decay, or excessive twist (spiral grain with a slope of grain relative to the longitudinal axis of the log exceeding 1 in 8). Ensure that knots in the middle half of the stringer length do not significantly affect structural capacity.

If SHOWN ON THE DRAWINGS, peel logs and provide preservative treatment as SHOWN ON THE DRAWINGS. Obtain written approval from the CO for all logs to be used in the structure.

559.04 Timber & Lumber. Furnish structural lumber and timber in accordance with the species, grades, and dimensions SHOWN ON THE DRAWINGS and in accordance with Section 557.

559.05 Aggregate. When required, furnish aggregate for decking or surfacing to meet the requirements SHOWN ON THE DRAWINGS.

Construction

559.06 General. Perform excavation, foundation, backfill, and embankment work specified in Sections 203 and 206, as applicable.

Handle all logs and timber carefully to prevent damage to the wood and/or preservative treatment.

Dispose of all debris resulting from operations in accordance with Section 202.

Construct abutments and pier as SHOWN ON THE DRAWINGS.

559.07 Performance. Construct bridge superstructure and substructures as SHOWN ON THE DRAWINGS, with attention paid to the details of erection, fit-up, and connection. Obtain written approval for all deviations from the CO.

Place timber caps to obtain even and uniform bearing over the tops of supporting posts or piles and with post and pile ends in true alignment. Secure all caps as SHOWN ON THE DRAWINGS.

Match stringers for size at the bearings and place them in position so that the crown is up. Alternate stringers butt to tip. Locate any knots that may affect the strength of the member in the top portion of the stringer.

Cut stringers to length with a square cut. Remove sufficient material from the top surface of the log stringer to provide an adequate bearing area for the decking as SHOWN ON THE DRAWINGS. Do not allow hewing to exceed 3/4 inch in depth at the small end of the log. Do not allow hewing of the top of the butt end to exceed 3 inches in depth for a distance not to exceed one-fourth span length.

Cut or hew the bottom surface of the small end of the stringer logs only to the depth necessary to achieve the required bearing area. Block or shim tip ends that are smaller than the largest tip. Cut or dap butt ends to the depth of the largest top end. Allow the maximum slope of any dap to be 1 to 10. Make top and bottom cuts parallel. Require shims or blocks used under small ends to cover the entire bearing area.

Notch all logs together, including face logs, tie logs, mud sills, and anchor logs as SHOWN ON THE DRAWINGS, and drift pin all connections.

Use an approved type of suitable granular, free-draining material and/or rock for backfill when crib abutments are to be constructed.

Use tiebacks or other abutment anchoring devices as SHOWN ON THE DRAWINGS or as approved in writing by the CO.

Measurement

559.08 Method. Use the method of measurement that is DESIGNATED IN THE SCHEDULE OF ITEMS.

When untreated and treated timber and lumber is measured, measure by the cubic foot of timber and lumber in place in the completed structure. Compute the quantities from nominal cross section dimensions and actual lengths.

When bridge railing is measured, measure under Subsection 556.11. When concrete is measured, measure under Subsection 552.21.

Measure log bridges on a lump sum basis, including all work necessary to furnish, prepare, and install the log portions of the bridge superstructure and substructure units.

Payment

559.09 Basis. The accepted quantities will be paid for at the contract unit price for each PAY ITEM DESIGNATED IN THE SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item	**Pay Unit**
559(01) Log bridge	Lump Sum

Section 561 - Structural Concrete Bonding

Description

561.01 Work. Repair cracks in concrete structures by pressure injecting epoxy.

Materials

561.02 Requirements. Furnish material that conforms to specifications in the following subsections:

Epoxy Resin Adhesives	725.21
Low-Strength Grout	701.03(b)
Polymer Grout	701.05

Construction

561.03 Crack Preparation. Provide notice of crack sealing at least 14 days before beginning work. The work areas will be identified and the locations of the cracks to be repaired will be marked.

Remove all dirt, laitance, and other debris from the exterior and interior of cracks. Apply a temporary surface seal material to the face of cracks. Use surface seal material with sufficient strength and adhesion to confine the injected epoxy material until cured.

Provide openings (entry ports) in the surface seal along the crack. Make the distance between entry ports at least the thickness of the concrete member being repaired.

After the injection adhesive has cured, remove the surface seal. Finish the face of the crack and entry ports flush with the adjacent surface.

561.04 Injection Procedures. Begin injecting epoxy at the lowest entry port. Continue injection at the first port until epoxy begins to flow out of the next highest port. Plug the first port and inject epoxy in the second port until the epoxy flows from the next highest port. Continue this sequence until the entire crack is filled. Use a two-component epoxy system. Maintain the mix ratio for the epoxy as prescribed by the manufacturer within 5 percent by volume at any discharge pressure not to exceed 200 pounds per square inch. Do not use solvents to thin the epoxy.

Use positive inline displacement-type equipment to meter, mix, and inject the epoxy at pressures not to exceed 200 pounds per square inch.

(a) Test for Proper Ratio. Perform this test for each injection unit at the beginning and end of every day that the unit is used. Disconnect the mixing head of the injection equipment and pump the two adhesive components through a ratio check device with two independent valved nozzles capable of controlling flow rate and back pressure by opening or closing valves on the check device. Use a pressure gage capable of sensing the back pressure behind each valve to adjust the discharge pressure to 200 pounds per

square inch for both epoxy components. Simultaneously discharge both epoxy components into separate calibrated containers. Compare the discharged amounts to determine the mix ratio.

After the test is completed at 200 pounds per square inch discharge pressure, repeat the procedures for zero pounds per square inch discharge pressure.

(b) Test for Pressure Check. Perform this test for each injection unit at the beginning and end of every day that the unit is used.

Disconnect the mixing head of the injection equipment and attach the two adhesive component delivery lines to a pressure check device with two independent valved nozzles capable of controlling flow rate and pressure by opening or closing the valves. Use a pressure gage capable of sensing the pressure buildup behind each valve. Close the valves on the pressure check device and operate the equipment until the gage pressure on each line reads 200 pounds per square inch. When the pumps are stopped, the gage pressure must not drop below 190 pounds per square inch within 3 minutes.

(c) Records. Maintain and make available complete and accurate records of the ratio check tests and the pressure check tests. Additional ratio and pressure check tests may be required.

561.05 Coring. Take one 2-inch diameter test core, in accordance with AASHTO T 24, for every 50 feet of repaired crack at designated locations. The crack repair is acceptable if the core sample indicates that 90 percent or more of the crack has been successfully bonded.

When a test core shows that the epoxy bonding has penetrated less than 90 percent of the crack volume within the core sample, redo that 50 foot crack segment, or the segment that the core represents, and resample. Repeat this procedure until acceptable crack repair is achieved.

Fill all sample core holes with polymer grout and finish the surface to match the adjacent concrete.

Measurement

561.06 Method. Use the method of measurement that is DESIGNATED IN THE SCHEDULE OF ITEMS.

Measure crack preparation by the linear foot or lump sum. Measure structural concrete bonding by the linear foot, gallon, or lump sum. When measurement is by the linear foot, measure the actual linear feet of surface crack acceptably repaired.

When measurement is by the gallon, measure the actual number of gallons of bonding material injected in the marked cracks that are acceptably repaired.

Payment

561.07 Basis. The accepted quantities will be paid for at the contract unit price for each PAY ITEM DESIGNATED IN THE SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item		`Pay Unit
561(01)	Structural concrete bonding	Linear Foot
561(02)	Structural concrete bonding	Gallon
561(03)	Structural concrete bonding	Lump Sum
561(04)	Crack preparation	Linear Foot
561(05)	Crack preparation	Lump Sum

Section 562 - Forms & Falsework

Description

562.01 Work. Design, construct, and remove forms and falsework to temporarily support concrete, girders, and other structural elements until the structure is completed to the point where it can support itself.

Design & Construction

562.02 Drawings. When complete details for forms and falsework are not shown, prepare and submit drawings as SHOWN ON THE DRAWINGS or as directed in the SPECIAL PROJECT SPECIFICATIONS. Perform the following, as applicable:

(a) Design and show the details for constructing safe and adequate forms and falsework that provide the necessary rigidity, support the loads imposed, and produce the required lines and grades in the finished structure. See Subsection 562.03 for design loads; Subsection 562.04 for design stresses, loadings, and deflections; and Subsection 562.05 for manufactured assemblies.

(b) Show the maximum applied structural load on the foundation material. Include a drainage plan or description of how foundations will be protected from saturation, erosion, and/or scour. See Subsection 562.06.

(c) Precisely describe all proposed material. Describe the material that is not describable by standard nomenclature (such as AASHTO or ASTM specifications) based on manufacturer's tests, and recommended working loads. Evaluate falsework material and ascertain whether the physical properties and conditions of the material are such that the material can support the loads assumed in the design.

(d) Furnish design calculations and material specifications showing that the proposed system will support the imposed concrete pressures and other loads. Provide an outline of the proposed concrete placement operation listing the equipment, labor, and procedures to be used for the duration of each operation. Include proposed placement rates and design pressures for each pour. Include a superstructure placing diagram showing the concrete placing sequence and construction joint locations.

(e) Provide design calculations for proposed bridge falsework. Appoint a licensed professional engineer proficient in structural design to design, sign, and seal the drawings. Ensure that the falsework design calculations show the stresses and deflections in load supporting members.

(f) Show anticipated total settlements of falsework and forms. Include Falsework footing settlement and joint takeup. Design for anticipated settlements not to exceed 1 inch. Design and detail falsework supporting deck slabs and overhangs

on girder bridges so there is no differential settlement between the girders and the deck forms during placement of deck concrete. Design and construct the falsework to elevations that include anticipated settlement during concrete placement and required camber to compensate for member deflections during construction.

(g) Show the support systems for form panels supporting concrete deck slabs and overhangs on girder bridges.

(h) Show details for strengthening and protecting falsework over or adjacent to roadways and railroads during each phase of erection and removal. See Subsection 562.07.

(i) Include intended steel erection procedures with calculations in sufficient detail to substantiate the girder geometry. See Subsection 562.08.

(j) Submit details of proposed anchorage and ties for void forms. See Subsection 562.10 for void form requirements.

Submit separate falsework drawings for each structure, except for identical structures with identical falsework design and details. Do not start construction of any unit of falsework until the drawings for that unit are reviewed and accepted.

562.03 Design Loads. Conform to the following:

(a) Vertical Design Loads. Dead loads include the weight of concrete, reinforcing steel, forms, and falsework. Consider the entire superstructure, or any concrete mass being supported by falsework, to be a fluid dead load with no ability to support itself. If the concrete is to be prestressed, design the falsework to support any increased or readjusted loads caused by the prestressing forces.

Assume that the density of concrete, reinforcing steel, and forms is not less than 160 pounds per cubic foot for normal concrete, and not less than 130 pounds per cubic foot for lightweight concrete.

Consider live loads to be the actual mass of equipment to be supported by Falsework applied as concentrated loads at the point of contact plus a uniform load of not less than 20 pounds per square foot applied over the area supported, plus 75 pounds per linear foot applied at the outside edge of deck falsework overhangs.

The total vertical design load for falsework is the sum of vertical dead and live loads. Use a total vertical design load of not less than 100 pounds per square foot.

(b) Horizontal Design Loads. Use an assumed horizontal design load on Falsework towers, bents, frames, and other falsework structures to verify lateral stability. The assumed horizontal load is the sum of the actual horizontal loads due to equipment, construction sequence, or other causes and an allowance for wind. However, in no case is

the assumed horizontal load to be less than 2 percent of the total supported dead load at the location under consideration.

The minimum wind allowance for each heavy-duty steel shoring with a vertical load carrying capacity exceeding 30 kips per leg is the sum of the products of the wind impact area, shape factor, and applicable wind pressure value for each height zone. The wind impact area is the total projected area of all the elements in the tower face normal to the applied wind. Assume that the shape factor for heavy-duty shoring is 2.2. Determine design wind pressure values from Table 562-1.

Table 562-1. - Design wind pressure - heavy duty steel shoring.

Height Zone Above Ground (feet)	Wind Pressure Value - psf	
	Adjacent to Traffic	At Other Locations
0	20	15
30 - 50	25	20
50 - 100	30	25
Over 100	35	30

The minimum wind allowance on all other types of falsework, including Falsework supported on heavy-duty shoring, is the sum of the products of the wind impact area and the applicable wind pressure value for each height zone. The wind impact area is the gross projected area of the falsework and unrestrained portion of the permanent structure, excluding the areas between falsework posts or towers where diagonal bracing is not used. Determine design wind pressure values from Table 562-2.

Table 562-2. - Design wind pressure - other types of falsework.

Height Zone Above Ground (feet)	Wind Pressure Value - psf	
	For Members Over and Bents Adjacent to Traffic Openings	At Other Locations
0	2.0 Q	1.5Q
30 - 50	2.5 Q	2.0Q
50 - 100	3.0 Q	2.5Q
Over 100	3.5 Q	3.0Q

Note: Q = 1 + 0.2W, but not more than 10. W is the width of the falsework system in feet measured in the direction of the wind force being considered.

Design the falsework to have sufficient rigidity to resist the assumed horizontal load without vertical dead load. Neglect the effects of frictional resistance.

(c) Lateral Fluid Pressure. For concrete with retarding admixture, fly ash, or other pozzolan replacement for cement, design forms, form ties, and bracing for a lateral fluid pressure based on concrete with a density of 150 pounds per cubic foot. For concrete containing no pozzolans or admixtures, which affect the time to initial set, determine the

lateral fluid pressure based on concrete temperature and rate of placement in accordance with ACI standard 347R, "*Guide for Formwork for Concrete."*

562.04 Design Stresses, Loads, & Deflections. The allowable maximum design stresses and loads listed in this section are based on the use of undamaged, highquality material. If lesser quality material is used, reduce the allowable stresses and loads. Do not exceed the following maximum stresses, loads, and deflections in the falsework design:

(a) Timber. For timber, use the following values:

Compression perpendicular to the grain	= 450 psi
Compression parallel to the grain[1]	= 480,000 psi/$(L/d)^2$

[1]Compression parallel to the grain is not to exceed 1,600 pounds per square inch.

where

L = unsupported length.
d = least dimension of a square or rectangular column or the width of a square of equivalent cross-sectional area for round columns

Flexural stress[1]	= 1,800 psi

[1]Reduce flexural stress to 1,450 psi for members with a nominal depth of 8 inches or less.

Horizontal shear	= 190 psi
Axial tension	= 1,200 psi

Deflection due to the weight of concrete may not exceed 1/500 of the span, even if the deflection is compensated for by camber strips.

The modulus of elasticity (E) for timber	= 1.6 x 10^6 psi
Maximum axial loading on timber piles	= 45 tons

Design timber connections in accordance with the stresses and loads allowed in the "National Design Specification for Wood Construction," published by the National Forest Products Association, except:

(1) Reductions in allowable loads required for high moisture condition of the lumber and service conditions do not apply.

(2) Use 75 percent of the tabulated design value as the design value of bolts in two member connections (single shear).

(b) Steel. For identified grades of steel, do not exceed the design stresses (other than stresses due to flexural compression) specified in the "Manual of Steel Construction," Allowable Stress Design, as published by the AISC.

When the grade of steel cannot be positively identified, do not exceed the design stresses, other than stresses due to flexural compression, specified in the AISC Manual for ASTM A 36 steel or the following:

Tension, axial and flexural = 22,000 psi
Compression, axial[1] = $16{,}000 - 0.38(L/r)^2$ psi

[1]L/r is not to exceed 120.

Shear on the web gross section of rolled shapes = 14,500 psi
Web crippling for rolled shapes = 27,000 psi

For all grades of steel, do not exceed the following design stresses and deflection:

Compression, flexural[1] = $\dfrac{12{,}000{,}000}{Ld/bt}$ psi

[1]Not to exceed 22,000 psi for unidentified steel or steel conforming to ASTM A 36. Not to exceed 0.6 F_y for other identified steel.

where

L = unsupported length
d = least dimension of a square or rectangular column or the width of a square of equivalent cross sectional area for round columns or depth of beams
b = width of the compression flange
t = thickness of the compression flange
F_y = specified minimum yield stress for the grade of steel used

Deflection due to the mass of concrete may not exceed 1/500 of the span, even if the deflection is compensated for by camber strips.

The modulus of elasticity (E) for steel = 30×10^6 psi

(c) Other Requirements. Limit falsework spans supporting T-beam girder bridges to 14 feet plus 8.5 times the overall depth of the T-beam girder.

562.05 Manufactured Assemblies. For jacks, brackets, columns, joists, and other manufactured devices, do not exceed the manufacturer's recommendations or 40 percent of the ultimate load-carrying capacity of the assembly based on the manufacturer's tests or additional tests ordered. Limit the maximum allowable dead load deflection of joists to 1/500 of their spans.

Furnish catalog or equivalent data showing the manufacturer's recommendations, or perform tests, as necessary, to demonstrate the adequacy of any manufactured device proposed for use. Do not substitute other manufacturers' components unless the manufacturer's data encompass such substitutions, or field tests reaffirm the integrity of the system.

If a component of the falsework system consists of a steel frame tower more than two or more tiers high, the differential leg loading within the steel tower unit shall not exceed 4 to 1. An exception may be approved if the manufacturer of the steel frame certifies, based on manufacturer's tests, that the proposed differential loadings are not detrimental to the safe load-carrying capacity of the steel frame.

562.06 Falsework Foundations. Field-verify all ground elevations at proposed foundation locations before design.

Where spread footing type foundations are used, determine the bearing capacity of the soil. The maximum allowable bearing capacity for foundation material, other than rock, is 2 tons per square foot.

Do not locate the edge of footings closer than 12 inches from the intersection of the bench and the top of the slope. Unless the excavation for footings is adequately supported by shoring, do not locate the edge of the footings closer than 4 feet or the depth of excavation, whichever is greater, from the edge of the excavation.

When a pile type foundation is used, use in accordance with Section 551. When falsework is supported by footings placed on paved, well-compacted slopes of berm fills, do not strut the falsework to columns unless the column is founded on rock or supported by piling.

Size spread footings to support the footing design load at the assumed bearing capacity of the soil without exceeding anticipated settlements. Provide steel reinforcement in concrete footings.

When individual steel towers have maximum leg loads exceeding 30 kips, provide for uniform settlement under all legs or each tower under all loading conditions.

Protect the foundation from adverse effects for the duration of its use. Advise the CO of actions that will be taken to protect the foundation.

562.07 Falsework Over or Adjacent to Roadways & Railroads. Design and construct the falsework to be protected from vehicle impact. This includes Falsework posts that support members crossing over a roadway or railroad and other Falsework posts if they are located in the row of falsework posts nearest to the roadway or railroad and if the horizontal distance from the traffic side of the falsework to the edge of pavement or to a point 10 feet from the centerline of track is less than the total height of the falsework.

Provide additional features to ensure that this falsework will remain stable if subjected to impact by vehicles. Use vertical design loads for these falsework posts, columns, and towers (but not footings) that are not less than either of the following:

(a) 150 percent of the design load calculated in accordance with Subsection 562.03, but not including any increased or readjusted loads caused by prestressing forces.

(b) The increased or readjusted loads caused by prestressing forces.

Install temporary traffic barriers before erecting falsework towers or columns adjacent to an open public roadway. Locate barriers so that falsework footings or pile caps are at least 3 inches clear of concrete traffic barriers, and all other Falsework members are at least 12 inches clear. Do not remove barriers until approved.

Use falsework columns that are steel with a minimum section modulus about each axis of 9.5 cubic inches or sound timbers with a minimum section modulus about each axis of 250 cubic inches.

Mechanically connect the base of each column or tower frame supporting Falsework over or immediately adjacent to an open public road to its supporting footing or provide other lateral restraint to withstand a force of not less than 2,000 pounds applied to the base of the column in any direction. Mechanically connect such columns or frames to the falsework cap or stringer to resist a horizontal force of not less than 1,000 pounds in any direction. Neglect the effects of frictional resistance.

For exterior girders upon which overhanging bridge deck falsework brackets are hung, brace or tie them to the adjacent interior girders as necessary to prevent rotation of the exterior girders or overstressing of the exterior girder web.

Mechanically connect all exterior falsework stringers and stringers adjacent to the end of discontinuous caps, the stringer or stringers over points of minimum vertical clearance, and every fifth remaining stringer to the falsework cap or framing. Provide mechanical connections capable of resisting a load in any direction, including uplift on the stringer, of not less than 500 pounds. Install connections before traffic is allowed to pass beneath the span.

Use 5/8-inch-diameter or larger bolts to connect timber members used to brace falsework bents located adjacent to roadways or railroads.

Sheath falsework bents within 20 feet of the centerline of a railroad track solid in the area between 3 and 16 feet above the track on the side facing the track. Construct sheathing of plywood not less than 5/8 inch thick or lumber not less than 1-inch nominal thickness. Provide adequate bracing on such bents so that the bent resists the required assumed horizontal load or 5,000 pounds; whichever is greater, without the aid of sheathing.

Provide at least the minimum required vertical and horizontal clearances through falsework for roadways, railroads, pedestrians, and boats.

562.08 Falsework for Steel Structures. Conform to the following:

a) Use falsework design loads consisting of the mass of structural steel, the load of supported erection equipment, and all other loads supported by the falsework.

(b) Design falsework and forms for concrete supported on steel structures so that loads are applied to girder webs within 6 inches of a flange or stiffener. Distribute

the loads in a manner that does not produce local distortion of the web. Do not use deck overhang forms that require holes to be drilled in the girder webs.

(c) Strut and tie exterior girders supporting overhanging deck falsework brackets to adjacent interior girders to prevent distortion and overstressing of the exterior girder web.

(d) Do not apply loads to existing, new, or partially completed structures that exceed the load-carrying capacity of any part of the structure in accordance with the Load Factor Design methods of the AASHTO *"Standard Specifications for Highway Bridges"* using Load Group IB.

(e) Build supporting falsework that will accommodate the proposed method of erection without overstressing the structural steel, and will produce the required final structural geometry, intended continuity, and structural action.

562.09 Falsework Construction. Construct falsework as SHOWN ON THE DRAWINGS.

When welding is required, submit a welder certification for each welder, in accordance with Subsection 555.18.

Build camber into the falsework to compensate for falsework deflection and anticipated structure deflection. Camber as SHOWN ON THE DRAWINGS or specified by the CO is for anticipated structure deflection only.

Attach tell-tales to soffit of concrete forms in enough systematically placed locations to be able to determine from the ground the total settlement of the structure while concrete is placed.

Do not apply dead loads, other than forms and reinforcing steel, to any Falsework until authorized.

When the falsework installation is complete and when SHOWN ON THE DRAWINGS or specified in the SPECIAL PROJECT SPECIFICATIONS, have the falsework inspected by a licensed professional engineer proficient in structural engineering. Certify in writing that the falsework installation conforms to accepted falsework drawings, specifications, and acceptable engineering practices. Provide a copy of the certification to the CO prior to concrete placement.

Discontinue concrete placement and take corrective action if unanticipated events occur, including settlements that cause a deviation of more than 3/8 inch from those SHOWN ON THE DRAWINGS. If satisfactory corrective action is not taken before initial set, remove all unacceptable concrete.

562.10 Forms. For exposed concrete surfaces, use U.S. Product Standard PS 1 for Exterior B–B (Concrete Form) Class I plywood or other approved material that will produce a smooth and uniform concrete surface. Use only form panels in good condition and free of defects on exposed surfaces. If form panel material other than plywood is

used, ensure that it has flexural strength, modulus of elasticity, and other physical properties equal to or greater than the physical properties for the type of plywood specified.

Furnish and place form panels for exposed surfaces in uniform widths of not less than 3 feet and in uniform lengths of not less than 6 feet, except where the width of the member formed is less than 3 feet.

Arrange panels in symmetrical patterns conforming to the general lines of the structure. Place panels for vertical surfaces with the long dimension horizontal and with horizontal joints level and continuous. For walls with sloping footings that do not abut other walls, footing.

Precisely align form panels on each side of the panel joint by means of supports or fasteners common to both panels. Provide ¾ inch triangular fillets at all sharp edges of the concrete, unless otherwise SHOWN ON THE DRAWINGS.

Devices may be cast into the concrete for later use in supporting forms or for lifting precast members. Do not use driven devices for fastening forms or form supports to concrete. Use form ties consisting of form bolts, clamps, or other devices necessary to prevent spreading of the forms during concrete placement.

Do not use form ties consisting of twisted wire loops. Use form ties and anchors that can be removed without damaging the concrete surface. Construct metal ties or anchorages within the forms to permit their removal to a depth of at least 1 inch from the face without damage to the concrete. Fill cavities with cement mortar in accordance with Subsection 701.04, and finish to a sound, smooth, uniform colored surface.

Construct all exposed concrete surfaces that will not be completely enclosed or hidden below the permanent ground surface so the formed surface of the concrete does not undulate more than 3/32 inch or 1/360 of the center-to-center distance between studs, joists, form stiffeners, form fasteners, or wales. Interior surfaces of underground drainage structures are considered to be completely enclosed surfaces. Form all exposed surfaces for each element of a concrete structure with the same forming material or with material that produces similar surface textures, color, and appearance.

Support forms for cast-in-place concrete bridge decks on the girders upon which the deck is to be cast. Do not shore deck forms to the ground or to the substructure.

Support roadway slab forms of box girder type structures on wales or similar supports fastened, as nearly as possible, to the top of the web walls.

Construct concrete forms mortar-tight, true to the dimensions, lines, and grades of the structure, and of sufficient strength to prevent appreciable deflection during placement of concrete. Place all material required to be embedded in the concrete before concrete placement. Clean inside surfaces of forms of all dirt, mortar, and foreign material. Remove all loose material before the completion of forming for the roadway deck slab of

cast-in-place box girders or cells or voids of other members in which the forms are to either remain in place or be removed.

Form exposed curved surfaces to follow the shape of the curve. However, on any retaining walls that follow a horizontal curve, the wall stems may be a series of short chords if all of the following conditions apply:

- The chords within the panel are the same length.
- The chords do not vary from a true curve by more than 9/16 inches at any point.
- All panel points are on the true curve.

When architectural treatment is required, make the angle points for chords in wall stems fall at vertical rustication joints.

Coat with form oil all forms to be removed. Use commercial-quality form oil or an equivalent coating that permits release of the forms and does not discolor the concrete. Do not place concrete in forms until the forms have been inspected and approved.

(a) Stay-in-Place Deck Forms. Use permanent or stay-in-place forms only when SHOWN ON THE DRAWINGS.

Fabricate permanent steel bridge deck forms and supports from steel conforming to ASTM A 653, coating designation G210, any Grade except Grade 50, Class 3.

Install forms in accordance with approved fabrication and erection drawings. Do not rest form sheets directly on the top of stringer or floor beam flanges. Securely fasten sheets to form supports. Place form supports in direct contact with the stringer flange or floor beam. Make all attachments with permissible welds, bolts, or clips. Do not weld form supports to flanges of steels not considered weldable or to portions of flanges subject to tensile stresses.

Clean, wire brush, and paint with two coats of zinc dust zinc-oxide primer (FSS TT–P–641 Type II, no color added) any permanently exposed form metal where the galvanized coating has been damaged. Minor heat discoloration in areas of welds need not be touched up.

Locate transverse construction joints in slabs at the bottom of a flute. Field drill ¼ inch diameter weep holes at not less than 12 inches on center along the line of the joint.

(b) Void Forms. Store void forms in a dry location to prevent distortion. Secure the forms using anchors and ties that leave a minimum of metal or other supporting material exposed at the bottom of finished slab.

Make the outside surface of the forms waterproof. Cover the ends with waterproof mortar-tight caps. Use a premolded ¼ -inch thick rubber joint filler around the perimeter of the caps to permit expansion.

Provide a PVC vent near each end of each void form. Construct vents so the vent tube does not extend more than ½ inch below the bottom surface of the finished concrete after form removal. Protect void forms from the weather until concrete is placed.

(c) Metal Forms. The specifications for forms relative to design, mortar tightness, filleted corners, beveled projections, bracing, alignment, removal, reuse, and oiling also apply to metal forms.

562.11 Removal of Forms & Falsework. Remove all forms except:

(a) Interior soffit forms for roadway deck slabs of cast-in-place box girders.

(b) Forms for the interior voids of precast members.

(c) Forms for abutments or piers when no permanent access is available into the cells or voids.

To facilitate finishing, when approved by the CO, the removal of forms that do not support the dead load of concrete members and of forms for railings and barriers may begin 24 hours after the concrete for the member has been placed. Protect exposed concrete surfaces from damage. Cure all exposed concrete surfaces in accordance with Subsection 552.17, if forms are removed less than 7 days after concrete placement.

Do not remove forms and falsework until the concrete strength and time requirements in Table 562-3 have been met.

Do not remove falsework under concrete that has been cured at a temperature continuously under 50 °F without first determining if the concrete has gained the specified strength, no matter how much time has passed.

Ensure that substructure concrete has reached the required 28-day compressive strength prior to erecting any superstructure or additional substructure elements, unless approved otherwise by the CO.

Do not release falsework in any span in continuous structures until the first and second adjoining spans on each side have reached the strength specified herein or in the SPECIAL PROJECT SPECIFICATIONS.

Uniformly and gradually remove falsework for arch bridges, beginning at the crown and working toward the springing. Remove falsework for adjacent arch spans simultaneously.

Completely release the falsework under all spans of continuous structures before concrete is placed in curbs, railings, and parapets.

Remove forms from columns before releasing supports from beneath beams and girders in order to determine the condition of column concrete.

Remove all forms from the cells of concrete box girders unless otherwise SHOWN ON THE DRAWINGS or permitted by the CO. Leave no forms that might jeopardize drainage or enclosed utilities.

Do not release falsework for cast-in-place prestressed portions of structures until after the prestressing steel has been tensioned.

Do not remove falsework supporting the deck of rigid frame structures, excluding box culverts, until compacted backfill material has been placed against vertical legs of the frame.

Install a reshoring system if the falsework supporting the sides of girder stems with slopes steeper than 1:1 are removed before placing deck slab concrete. Design a reshoring system with lateral supports that resist all rotational forces acting on the stem, including those caused by the placement of deck slab concrete. Install the lateral supports immediately after each form panel is removed and before release of supports for the adjacent form panel.

Table 562-3. - Minimum form/support release criteria.

Structural Element	**% of Specified 28-Day Strength (f_c')**	**Minimum Number of Days Since Last Pour**	
		Standard Concrete	**Type II Concrete**
Columns and wall faces (not yet supporting loads)	*50*	3	2
Mass piers and mass abutments (not yet supporting loads) except pier caps	50	3	N/A
Box Girders	80	14	7
Simple span girders, T-beam girders, slab bridges, cross beams, caps, pier caps not continuously supported, struts, and top slabs of concrete box culverts	80	14	7
Trestle slabs where supported on wood stringers	70	10	4
Slabs and overhangs where supported on steel stingers or prestressed concrete girders	70	10	4
Pier caps continuously supported	60	7	3
Arches, continuous span bridges, and rigid frames	90	21	10

Completely remove falsework material. Remove falsework piling at least 2 feet below the surface of the original ground or stream bed. Where falsework piling is driven within the limits of ditch or channel excavation, remove the piling to at least 2 feet below the bottom and side slopes of the excavated areas.

Leave the forms for footings constructed within a cofferdam or crib in place when their removal would endanger the safety of the cofferdam or crib, and where the forms will not be exposed to view in the finished structure.

Remove all other forms, whether above or below groundline or water level.

Measurement & Payment
562.12 Method & Basis. Use the method of measurement that is DESIGNATED IN THE SCHEDULE OF ITEMS.

Do not measure forms and falsework for payment.

Section 563 - Painting

Description

563.01 Work. Apply protective coatings to metal, timber, or concrete surfaces to control corrosion and deterioration.

Materials

563.02 Requirements. Furnish material that conforms to specifications in the following section and subsections:

Boiled Linseed Oil	725.14(a)
Paint	708
Petroleum Spirits (Mineral Spirits)	725.14(b)
Water	725.01

Construction

563.03 Protection of Public, Property, & Workers. Comply with the SSPC's "SSPC–PA Guide 3 - A Guide to Safety in Paint Application" and with OSHA requirements. If the paint being removed is a hazardous material containing lead chromium, comply with all of the following:

- SSPC Guide 6I(CON)—"Guide for Containing Debris Generated During Paint Removal Operations."
- SSPC Guide 7I(DIS)—"Guide for the Disposal of Lead-Contaminated Surface Preparation Debris."
- 29 CFR 1926.62—"OSHA Construction Industry Standards for Lead."
- 40 CFR 50.6—"EPA National Primary and Secondary Ambient Air Quality Standards for Particulate Matter."
- 40 CFR, 50.12—"EPA National Primary and Secondary Ambient Air Quality Standards for Lead."
- 40 CFR, parts 260–268—"Resource Conservation and Recovery Act (RCRA)."

At least 28 days before beginning surface preparation, submit a written plan for approval that details the measures to be used for the protection of the environment, public, adjacent property, and the workers while performing the work. Include in the plan the following:

Manufacturer's material safety data sheets and product sheets for all cleaning and painting products.

(b) A detailed containment plan for removed material, cleaning products, and paint debris. Include details of attachment to the structure.

(c) A detailed disposal plan for removal, cleaning products, and paint debris.

(d) Specific safety measures to protect workers from site hazards, including falls, fumes, fires, or explosions.

(e) If paint being removed is hazardous material, include specific safety measures to comply with 29 CFR 1962.26, 40 CFR 50.6, 40 CFR 50.12, and 40 CFR, parts 260–268. Document compliance upon request.

(f) A written plan for emergency spill procedures.

(g) A competent person responsible for ensuring that all necessary health, safety, and containment measures are enacted and maintained.

After acceptance, perform work according to the plan. If the measures fail to perform as intended, immediately stop work and take corrective action. Collect and properly dispose of all material, including wastewater that is used in preparing, cleaning, or painting.

563.04 Protection of the Work. Use tarps, screens, paper, cloth, or other suitable means to protect adjacent surfaces that are not to be painted. Prevent contamination of freshly painted surfaces by dust, oil, grease, or other harmful and deleterious material.

563.05 Surface Preparation, General. Notify the CO in writing at least 7 days before beginning operations. Immediately before painting, prepare the surface according to the following:

(a) Clean the surface to the specified cleanliness level.

(b) Remove dirt, dust, and other contaminants from the surface using methods recommended by the paint manufacturer.

(c) Thoroughly dry the surface.

(d) Determine that the surface temperature is between 50 °F and 100 °F.

(e) Determine that the surface temperature is 5 °F or more above the dew point according to ASTM E 337.

(f) Determine that the humidity is 85 percent or less, unless specified otherwise on the manufacturer’s product data sheet.

Suitable engineering control, such as enclosures and dehumidification, may be used to provide the conditions required above.

563.06 Paint Application, General. Use safe handling practices that conform to the manufacturer's safety data sheet and instructions. Mix and apply paint according to the product instructions. Mix paint with mechanical mixers for a sufficient length of time to thoroughly blend the pigment and vehicle together. Continue the mixing during application. Do not thin paint that is formulated ready for application.

Paint in a neat and workmanlike manner that does not produce excessive paint buildup, runs, sags, skips, holidays, or thin areas in the paint film. Measure the wet film thickness during application, and adjust the application rate such that, after curing, the desired dry film thickness is obtained. Apply paint by brush, spray, roller, or any combination thereof if permitted by the manufacturer's product data sheet.

Use brushes that have sufficient bristle body and length to spread the paint in a uniform film. Use round, oval-shaped, or flat brushes no wider than 4 3/4 inches. Evenly spread and thoroughly brush out the paint as it is applied.

Use airless or conventional spray equipment with suitable traps, filters, or separators to exclude oil and water from the compressed air. Use the spray gun tip sizes and pressures recommended by the manufacturer. Use compressed air that is free from oil or moisture and does not show black or wet spots when tested in accordance with ASTM D 4285.

Use rollers only on flat, even surfaces. Do not use rollers that leave a stippled texture in the paint film.

Use sheepskin daubers, bottle brushes, or other acceptable methods to paint surfaces that are inaccessible for painting by regular means.

Cure each coat of paint according to the manufacturer's recommendations. Correct all thin areas, skips, holidays, and other deficiencies before the next application of paint. Tint succeeding applications of paint to contrast with the paint being covered. The CO will approve the color for the finish coat before application.

Coat structures with the total thickness of undercoats before erection. Coat any surfaces that will be inaccessible after erection with the full number of required applications before erection. After erection and before applying the final coat, thoroughly clean all areas where coating has been damaged or has deteriorated, or where there are exposed unpainted surfaces, and spot coat with the specified undercoats to the specified thickness.

563.07 Structural Iron & Steel. Conform to the following:

(***a) Paint Systems.*** Conform to the following:

(1) New Surfaces or Surfaces With All Existing Paint Removed. Furnish a paint system shown in Table 563-1.

(2) Surfaces With Existing Sound Paint. Furnish a paint system that is compatible with the existing paint. Any of the systems listed in Table 563-2 or any system that is approved for use on steel structures by the State department of transportation in the State

in which the structure is located is acceptable if the proposed system is compatible with the existing system.

At least 14 days before ordering paint, verify compatibility of the proposed system with the existing system as follows:

(a) Select a test area of at least 30 square feet in a condition representative of the condition of the structure. Perform the specified level of surface preparation and apply the proposed system to the existing topcoat and primer. Watch for lifting, bleeding, blistering, wrinkling, cracking, flaking, or other evidence of incompatibility.

(b) Verify that no indication of incompatibility exists at least 14 days after the application of each product. Perform adhesion tests according to ASTM D 3359, method A. Notify the CO immediately if adhesive testing fails at the interface of the existing finish coat and primer. An adhesion failure indicates incompatibility. Choose a more compatible paint system.

(b) Surface Preparation. Do not remove sound paint unless SHOWN ON THE DRAWINGS.

(1) New Surfaces or Surfaces With All Existing Paint Removed. Remove all dirt, mill scale, rust, paint, and other foreign material from exposed surfaces by blast cleaning to near white metal in accordance with SSPC–SP 10.

Use compressed air that is free from oil or moisture and does not show black or wet spots when tested in accordance with ASTM D 4285. Do not use unwashed sand or abrasives that contain salts, dirt, oil, or other foreign matter. Before blast cleaning near machinery, seal all bearings, journals, motors, and moving parts against entry of abrasive dust.

Blast clean with clean, dry sand, mineral grit, steel shot, or steel grit. Use a suitable gradation to produce a dense, uniform anchor pattern. Produce an anchor profile height of 1 to 2 mils, but not less than that recommended by the manufacturer's product data sheet for the paint system specified. Measure anchor profile height using the tape method in accordance with ASTM D 4417.

The same day cleaning is performed, remove dirt, dust, and other debris from the surface by brushing, blowing with clean, dry air, or vacuuming and apply the first coat of paint to the blast-cleaned surfaces. If the cleaned surfaces rust or become contaminated before painting, repeat blast cleaning.

(*2) Surfaces With Existing Sound Paint.* Wash all areas to be painted with pressurized water to remove dirt, surface chalking, loose rust, and contaminants such as chlorides. Maintain a wash water pressure of at least 500 pounds per square inch. Capture all wash water and removed waste according to appropriate regulations.

Table 563-1. - Structural iron and steel coating systems for new surfaces and surfaces with all existing paint removed.

	Paint System[a]				
	1	**2**	**3**	**4**	**5**
Coat	**Aggressive Environments (Salt)**	**Aggressive Environments (Salt)**	**Aggressive Environments (Salt)**	**Less Aggressive Environments (No Salt)**	**Less Aggressive Environments (No Salt)**
Primer	Inorganic zinc, Type II, 3-4 mils dry	Zinc-rich epoxy 3-4 mils dry	Moisture-cured urethane 2-3 mils dry	Acrylic latex 2-3 mils dry	Low-VOC Alkyd 2-3 mils dry
Intermediate	Epoxy 3-4 mils dry	Epoxy 3-4 mils dry	Moisture-cured urethane 2-3 mils dry	Acrylic latex 2-3 mils dry	Low-VOC Alkyd 2-3 mils dry
Top	Aliphatic urethane 2-3 mils dry	Aliphatic urethane 2-3 mils dry	Moisture-cured or aliphatic urethane 2-3 mils dry	Acrylic latex 2-3 mils dry	Low-VOC Alkyd 2-3 mils dry
Total thickness	8 - 11 mils dry	8 - 11 mils dry	6 - 9 mils dry	6 - 9 mils dry	6 - 9 mils dry

a. System 1, 2, or 3 is for the corrosion protection of iron and steel in aggressively corrosive atmospheric environments, such as marine, industrial, or high-humidity environments, and in structures exposed to deicing salts. System 4 or 5 is for use in environments that are free from high concentrations of salts or pollutants that cause aggressive corrosion.

Table 563-2 - Structural iron and steel coating systems for surfaces with existing sound paint.

	Paint System[a]		
	6	**7**	**8**
Coat	**Aggressive Environments (Salt)**	**Less Aggressive Environments (No Salt)**	**Less Aggressive Environments (No Salt)**
Primer	Moisture-cured urethane 2-3 mils dry	Low -VOC Alkyd 2-3 mils dry	Low-viscosity epoxy sealer 1-2 mils dry
Intermediate	Moisture-cured urethane 2-3 mils dry	Low-VOC Alkyd 2-3 mils dry	Epoxy 3-4 mils dry
Top	Moisture-cured or aliphatic urethane 2-3 mils dry	Low-VOC silicone-alkyd 2-3 mils dry	Aliphatic urethane 2-3 mils dry
Total Thickness	6 - 9 mils dry	6 - 9 mils dry	6 - 9 mils dry

[a.] System 6 is for the corrosion protection of iron and steel in aggressively corrosive atmospheric environments, such as marine, industrial, or high-humidity environments, and in structures exposed to deicing salts. System 7 or 8 is for use in environments that are free from high concentrations of salts or pollutants that cause aggressive corrosion.

Clean according to SSPC–SP 2, Hand Tool Cleaning; SSPC–SP 3, Power Tool Cleaning; or SSPC–SP 6, Commercial Blast Cleaning, to remove dirt, loose mill scale, loose rust, or paint that is not firmly bonded to the underlying surface. Clean small areas that show pinhole corrosion, stone damage from traffic, or minor scratches. Clean at least 2 inches beyond the damaged areas. Feather edges of remaining old paint to achieve a reasonably smooth surface.

The same day hand- or power-tool cleaning is performed, remove dirt, dust, and other contaminants from the surface with solvent cleaning methods according to SSPC–SP 1, and spot paint all bare steel areas cleaned with the first coat of paint. If the cleaned surfaces rust or become contaminated before painting, repeat solvent cleaning. Repair all damage to sound paint by applying the entire system.

(c) Application of Paints. Apply each coat to the wet film thickness as recommended by the paint manufacturer to obtain the specified dry film thickness. Verify the application rate of each coat with a wet film paint thickness gauge immediately after applying paint to the surface. Confirm the application rate by measuring the dry film thickness after the solvent has evaporated from the surface.

For example, if 3 mils of dry thickness is desired and the volatile content of the paint is 50 percent, the wet film paint thickness gauge must read at least 6 mils immediately after application of the paint to achieve the desired dry coat thickness of 3 mils.

563.08 Painting Galvanized Surfaces. Clean and prepare the surface to be painted by washing with a mineral spirit solvent to remove all oil, grease, or other contaminants on the surface, in accordance with SSPC–SP 1.

Apply the coating system shown in Table 563-3 for other metals.

563.09 Painting Timber Structures. Dry timber to a moisture content of 20 percent or less. On previously painted timber, remove all cracked or peeled paint, loose chalky paint, dirt, and other foreign material by wire brushing, scraping, or other approved methods. On timber treated with creosote or oilborne pentachlorophenol preservative, wash and brush away visible salt crystals on the wood surface and allow to dry. Remove all dust or other foreign material from the surface to be painted.

Apply the coating system shown in Table 563-3. The primer may be applied before erection. After the primer dries and the timber is in place, fill all cracks, checks, nail holes, or other depressions flush with the surface using approved putty. Evenly spread and thoroughly work the paint into all corners and recesses. Allow the full thickness of the applied coat of paint to dry before applying the next coat.

563.10 Painting Concrete Structures. Clean and prepare the concrete surface to be painted by removing all laitance, dust, foreign material, curing compound, form oil, grease, or other deleterious material. If form oil, grease, or curing compound is present, wash the surface clean with a 5 percent solution of trisodium phosphate. After washing, thoroughly rinse the surface with clean water and allow to dry completely.

Table 563-3 - Coating systems for other structures.

Substrate	Paint Coatings			
	Primer	**Intermediate**	**Finish**	**Total Thickness**
Smooth Wood	Exterior wood primer[a] 2-3 mils dry	Exterior latex or alkyd 1-2 mils dry	Exterior latex or alkyd 1-2 mils dry	5 – 7 mils dry
Rough Lumber	Exterior latex or alkyd[a] 1-2 mils dry	Exterior latex or alkyd 1-2 mils dry	Exterior latex or alkyd 1-2 mils dry	4 – 6 mils dry
Concrete	Epoxy single coat 3-4 mils dry. For gloss finish, finish with aliphatic-polyurethane (2 mils dry).			3 – 6 mils dry
Masonry Block	Masonry block filler 2-3 mils dry	Exterior latex or alkyd 1-2 mils dry	Exterior latex or alkyd 1-2 mils dry	5 – 7 mils dry
Aluminum	Metal primer 1-2 mils dry	Exterior latex or alkyd 1-2 mils dry	Exterior latex or alkyd 1-2 mils dry	4 – 6 mils dry
Other Metals	Metal primer[b] 1-2 mils dry	Exterior latex or alkyd 1-2 mils dry	Exterior latex or alkyd 1-2 mils dry	4 – 6 mils dry

[a.] For untreated wood, thin the primer with up to 0.1 gallon of turpentine and 0.1 gallon linseed oil per gallon of paint.
[b.] For galvanized surfaces, use an epoxy primer (1-2 mils dry thickness) or a vinyl wash primer (1 mil dry thickness).

Give the cleaned surface a light abrasive sweep to remove mortar wash or other contaminants. Remove all residue and dust by hand, broom, compressed air, or other approved methods.

Apply the coating system shown in Table 563-3. Evenly spread and thoroughly work the paint into all corners and recesses. Allow the full thickness of the applied coat of paint to dry before applying the succeeding coat.

Measurement

563.11 Method. Use the method of measurement that is DESIGNATED IN THE SCHEDULE OF ITEMS.

Measure painting by the square foot or lump sum.

When measurement is by the square foot, measure the visible surface area painted.

Payment

563.12 Basis. The accepted quantities will be paid for at the contract unit price for each PAY ITEM DESIGNATED IN THE SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item		**Pay Unit**
563(01)	Painting, _____ structure *Description*	Lump Sum
563(02)	Painting, _____ structure *Description*	Square Foot

Section 564 - Bearing Devices

Description

564.01 Work. Furnish and install bridge bearings. Bearing devices are designated as elastomeric, rocker, roller, and sliding plate.

Materials

564.02 Requirements. Furnish material that conforms to specifications in the following subsections:

Elastomeric Bearing Pads 717.10
TFE Surfaces for Bearings.....717.11

Construction

564.03 General. Conform to the fallowing:

(a) Drawings. Prepare and submit drawings for the bearings in accordance with section 18, AASHTO "Standard Specifications for Highway Bridges," Division II, Volume II, when SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS. Show all details of the bearings, including the material proposed for use. Obtain approval before beginning fabrication.

(b) Fabrication. Fabricate bearings in accordance with Section 18 of the AASHTO "Standard Specifications for Highway Bridges," Division II, Volume II. Ensure that the surface finish of bearing components in contact with each other or with concrete, but not embedded in concrete, conforms to Subsection 555.08(e).

Preassemble bearing assemblies in the shop and check for proper completeness and geometry. Galvanize steel bearing components and anchor bolts in accordance with Subsection 717.07. Do not galvanize stainless steel bearing components or anchor bolts.

(c) Packaging, Handling, & Storage. Before shipping from the manufacturer, clearly identify each bearing component, and mark on its top the location and orientation in the structure. Securely bolt, strap, or otherwise fasten the bearings to prevent any relative movement.

Package bearings so they are protected from damage due to shipping, handling, weather, or other hazards. Do not dismantle bearing assemblies at the site except for inspection or installation.

Store all bearing devices and components at the worksite in a location that provides protection from environmental and physical damage.

***(d) Construction & Installation*.** Clean the bearings of all deleterious substances. Install the bearings at the positions SHOWN ON THE DRAWINGS. Set bearings and bearing

components to the dimensions SHOWN ON THE DRAWINGS or as prescribed by the manufacturer. Adjust in accordance with the manufacturer's instructions to compensate for installation temperature and future movements of the bridge.

Set bridge bearings level at the exact elevation and position. Provide full and even bearing on all external bearing contact surfaces. If bearing surfaces are at improper elevations or not level, or if bearings cannot otherwise be set properly, notify the CO and submit a written proposal to modify the installation for approval.

Bed metallic bearing assemblies that are not embedded in concrete on concrete with an approved filler or fabric material.

Set elastomeric bearing pads directly on properly prepared concrete surfaces without bedding material.

Machine all bearing surfaces that are seated directly on steel to provide a level and planar surface upon which to place the bearing.

564.04 Elastomeric Bearings. The bearings include nonreinforced pads (consisting of elastomer only) and reinforced bearings with steel or fabric laminates.

Reinforce elastomeric bearings that are more than 9/16 inch thick with laminates every 9/16 inch through the entire thickness.

If not specified, use 50 durometer elastomer that is capable of sustaining an average compressive stress of 1,000 psi.

Fabricate elastomeric bearings in accordance with AASHTO M 251. Use material that meets the flash tolerance, finish, and appearance requirements of the "Rubber Handbook" published by the Rubber Manufacturer's Association Incorporated, RMA F3 and T.063 for molded bearings and RMA F2 for extruded bearings. Determine compliance with AASHTO M 251, level I acceptance criteria.

Mark each reinforced bearing with indelible ink or flexible paint. Mark the order number, lot number, bearing identification number, and elastomer type and grade number. Unless otherwise specified, mark on a face that is visible after erection of the bridge. Furnish a list of all individual bearing numbers.

Place bearings on a level surface. Correct any misalignment in the support to form a level surface. Do not weld steel girders or base plates to the exterior plates of the bearing unless there is more than 1 ½ inches of steel between the weld and elastomer. Do not expose the elastomer or elastomer bond to instantaneous temperatures greater than 400 °F.

564.05 Rocker, Roller, & Sliding Bearings. When TFE coatings are required, use coatings that conform to Subsection 564.07.

Fabricate rocker, roller, and sliding bearings in accordance with the details SHOWN ON THE DRAWINGS and with Section 555. Perform fabrication in accordance with standard practice in modern commercial shops. Remove burrs, rough and sharp edges, and other flaws. Stress-relieve rocker, roller, and other bearings that are built up by welding sections of plate together before boring, straightening, or finished machining.

Thoroughly coat all contact surfaces with oil and graphite just before placing roller bearings. Install rocker, roller, and sliding bearings so they are vertical at the specified mean temperature after release of falsework and after any shortening due to prestressing forces. Take into account any variation from mean temperature of the supported span at time of installation and any other anticipated changes in length of the supported span.

Make sure the superstructure has full and free movement at movable bearings. Carefully position cylindrical bearings so that their axes of rotation align and coincide with the axis of rotation of the superstructure.

564.06 Masonry, Sole, & Shim Plates for Bearings. Provide metal plates used in masonry, sole, and shim plates that conform to AASHTO M 270, Grade 36.

Fabricate and finish steel in accordance with Section 555. Form holes in bearing plates by drilling, punching, or accurately controlled oxygen cutting. Remove all burrs by grinding.

Accurately set bearing plates in level position as SHOWN ON THE DRAWINGS and provide a uniform bearing over the bearing contact area. When plates are embedded in concrete, make provision to keep them in correct position as the concrete is placed.

564.07 TFE Surfaces for Bearings. Furnish TFE material that is factory bonded, mechanically connected, or recessed into the backup material, as SHOWN ON THE DRAWINGS.

Bond or mechanically attach the fabric containing TFE fibers to a rigid substrate. Use a fabric capable of carrying unit loads of 10,000 pounds per square inch without cold flow. Use a fabric-substrate bond capable of withstanding, without delamination, a shear force equal to 10 percent of the perpendicular or normal application loading, plus any other bearing shear forces.

Determine compliance using approved test methods and procedures in accordance with Section 18, subsection 18.8.3, AASHTO “Standard Specifications for Highway Bridges,” Division II, Volume II. If the test facility does not permit testing completed bearings, manufacture extra bearings and prepare samples of at least 100 kip capacity at normal working stresses.

Determine static and dynamic coefficient of friction at first movement of the test bearing at a sliding speed of less than 1 inch per minute. Ensure that the coefficient of friction does not exceed the coefficient of friction specified in Table 564-1 or by the manufacturer.

Table 564-1. - Coefficient of friction.

Material	Bearing Pressure (psi)	Friction Coefficient
Unfilled TFE, fabric containing TFE fibers, or TFE-perforated metal composite	500	0.08
	2,000	0.06
	3,500	0.04
Filled TFE	500	0.12
	2,000	0.10
	3,500	0.08
Interlocked bronze and filled TFE structures	500	0.10
	2,000	0.07
	3,500	0.05

Furnish a listing of all individual bearing numbers.

564.08 Anchor Bolts. Furnish wedge or thread anchor bolts that conform to ASTM A 307 or as SHOWN ON THE DRAWINGS.

Drill holes for anchor bolts and set them in Portland cement nonshrink grout or preset them before placing the concrete.

Adjust bolt locations for superstructure temperature as required. Do not restrict free movement of the superstructure at movable bearings through anchor bolts or nuts.

564.09 Bedding of Masonry Plates. Place filler or fabric as bedding material under masonry plates, as SHOWN ON THE DRAWINGS. Use the type of filler or fabric specified and install to provide full bearing on contact areas. Thoroughly clean the contact surfaces of the concrete and steel immediately before placing the bedding material and installing bearings or masonry plates.

Measurement

564.10 Method. Use the method of measurement that is DESIGNATED IN THE SCHEDULE OF ITEMS.

Measure bearing devices by the each.

Payment

564.11 Basis. The accepted quantities will be paid for at the contract unit price for each PAY ITEM DESIGNATED IN THE SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item		**Pay Unit**
564(01)	_____ bearing device	Each
	Description	